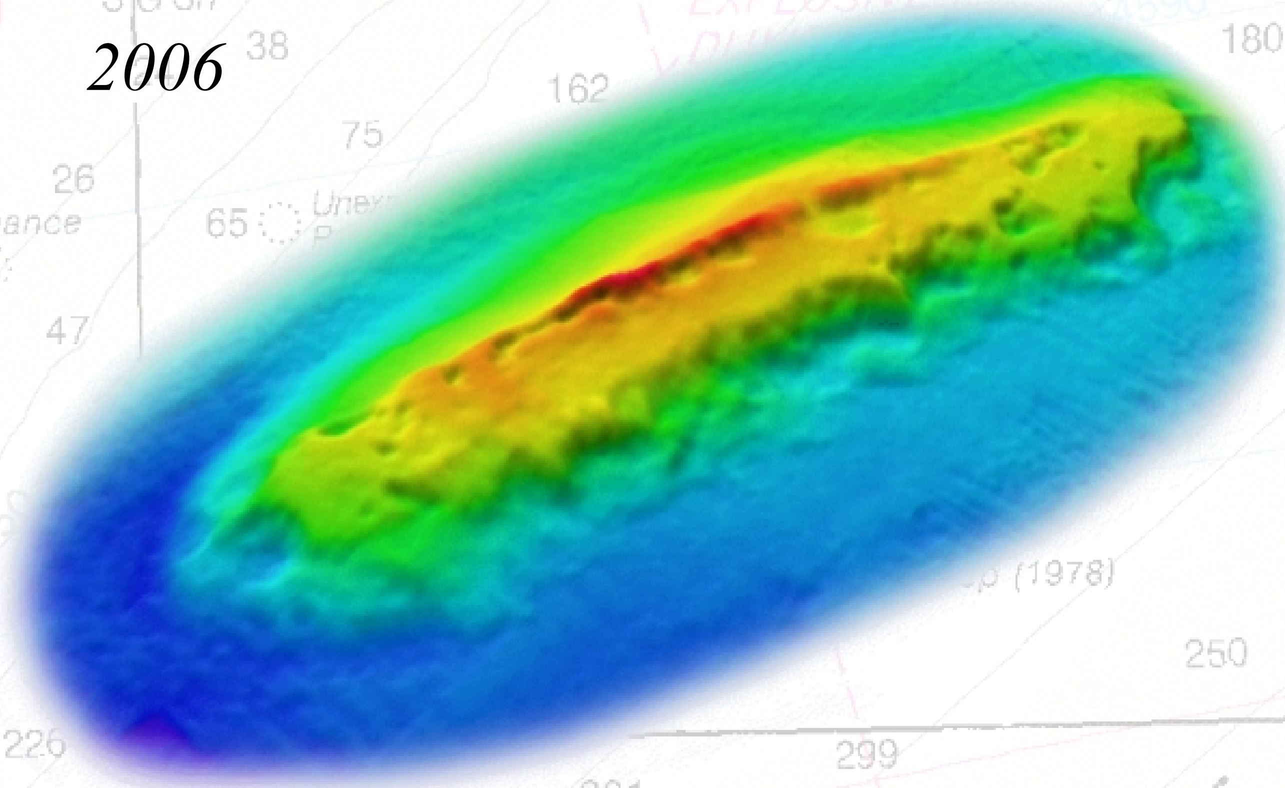
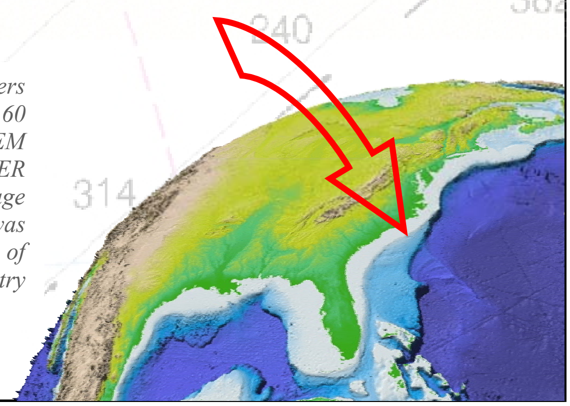
HYDROGRAPHIC SYSTEMS READINESS REVIEW

NOAA Ship NANCY FOSTER

2006



The above image is of a DTM of a 700-meter long ridge that rises 10 meters above the surrounding bathymetry along the edge of the continental shelf 60 nautical miles offshore Charleston, SC. The DTM was generated from EM 1002 multibeam sonar data acquired by NOAA Ship NANCY FOSTER during the ship's Hydrographic Systems Readiness Review trials. The image to the right is of a 3-D shaded relief model of a portion of the globe that was generated from XYZ data from the SRTM30_PLUS database, which is one of numerous relief databases that will ultimately be updated with bathymetry data acquired by NOAA Ship NANCY FOSTER.



HYDROGRAPHIC SYSTEMS READINESS REVIEW

NOAA SHIP NANCY FOSTER

2006

Prepared by:

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INTRODUCTION

NOAA Ship NANCY FOSTER, R352 (WTER), is a 57-m (187-ft) former Navy yard torpedo test craft that was transferred to NOAA in 2001. Built in 1991 by McDermott, Inc. in Amelia, Louisiana, the vessel's homeport is Charleston, SC. NANCY FOSTER has a welded steel hull, a moulded breadth of 12.1 m (40 ft), a full load displacement of 1,186.51 long tons, and a gross tonnage of 894 tons. The ship's complement includes five commissioned officers, three licensed engineers, ten crew, and up to 15 scientists.

NOAA Ship NANCY FOSTER supports research for NOAA's Office of Ocean and Coastal Resource Management, NOAA's Office of Ocean Exploration, and the National Sea Grant College Program. NOAA Ship NANCY FOSTER's missions call for a wide variety of operations, including bottom fish trawling, sediment sampling, core sampling, diving, sub-bottom profiling, and side scan and multibeam surveying. Past multibeam surveying operations employed temporary pole-mounted transducers and temporary positioning systems; however, to make multibeam data acquisition a more integrated component of the ship's research support, NOAA Aviation and Marine Operations (NMAO) funded a permanent installation of a Kongsberg EM 1002 multibeam sonar, an Applanix POS/MV positioning system, and other supporting equipment.

The Sea Acceptance Test (SAT) for the EM 1002 occurred March 6-10, 2006, offshore of Charleston, South Carolina. As Kongsberg's SAT report (Appendix 1) explains, the purpose of the SAT was to verify that the multibeam echosounder and the various peripheral systems function as an integrated mapping system. Present during the SAT, in addition to the ship's crew and a visiting contracted hydrographer, were representatives from Kongsberg and Office of Coast Survey (OCS). The OCS representatives also worked with the ship's hydrographic crew during this time to initiate a series of shipboard standard hydrographic systems operating procedures, covering survey planning, data acquisition, data processing, data quality control, and data submission.

This report, which is a hybrid of a hydrographic systems readiness review package and a data acquisition & processing report, serves two purposes: (1) to document the configuration and calibration of the overall multibeam system, including supporting equipment, and (2) asses the ability of the multibeam system to meet OCS hydrographic surveying requirements.

1. VESSELS

1.1. Vessel Static Offsets

In February, 2006, the Power & Control Systems Group of L3 Communications performed a full offset survey, in which the IMU, GPS antennas, EM1002 transducer, a number of permanent benchmarks, and the center of motion were surveyed with respect to a reference point (the ship's granite block). The survey report and independent supplemental AUTOCAD drawings of the major components of the multibeam system are located in Appendix 2.

1.2. Vessel Dynamic Offsets

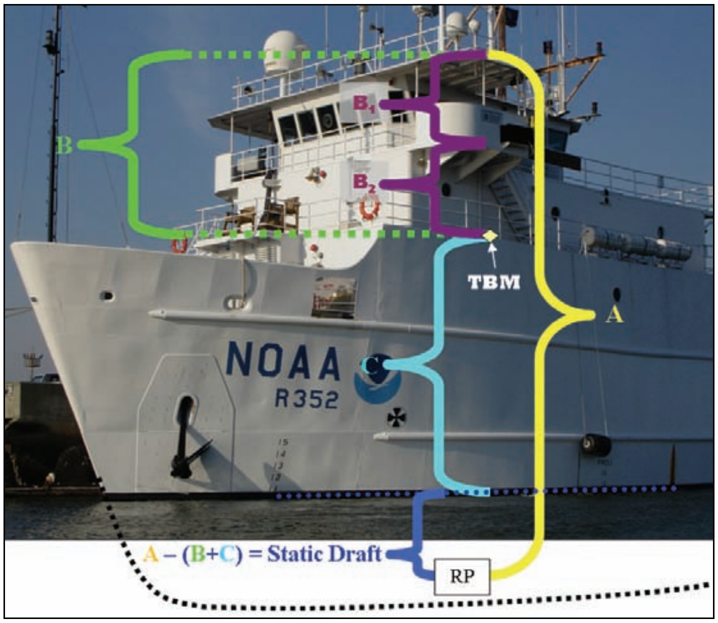
1.2.1. Static Draft

The static draft of the transducer is the distance from the phase center of the transducer (in the case of the EM 1002, the bottom face) to the water line. In MERLIN and CARIS, static draft is split into two separate measurements to be able to account for changes in loading conditions over time: the static vertical distance from the reference point (RP) to the transducer and the variable vertical distance from the RP to the water line. NANCY FOSTER has developed three methods to determine the variable component of the transducer static draft measurement: (1) a method that utilizes a benchmark on the flying bridge, (2) a method that utilizes the transducer's projection draft marks, and (3) a method that utilizes the ship's keel draft marks.

1.2.1.1. Benchmark Method

With the first method, illustrated in figure 1, the draft of the reference point is determined by measuring the vertical distance to the water surface from a temporary bench mark (labeled "TBM" in figure 1) on the lip on the edge of the 02 deck located near the along-ship position of the transducer and then subtracting that distance from the known starboard flying bridge bench mark-to-RP distance. The vertical component of the supplemental benchmark lever arm was tied into the ship's reference frame by measuring its vertical distance from the flying bridge starboard benchmark. Since there was not a direct line of sight from the flying bridge benchmark to the supplemental benchmark, the distance was divided into two measurements, B_1 and B_2. Incorporated into measurement B_1 is the thickness of the 02 and 03 deck plates (0.006 meter each).

Figure 1: ***Static Draft Determination - Bench Mark Method***

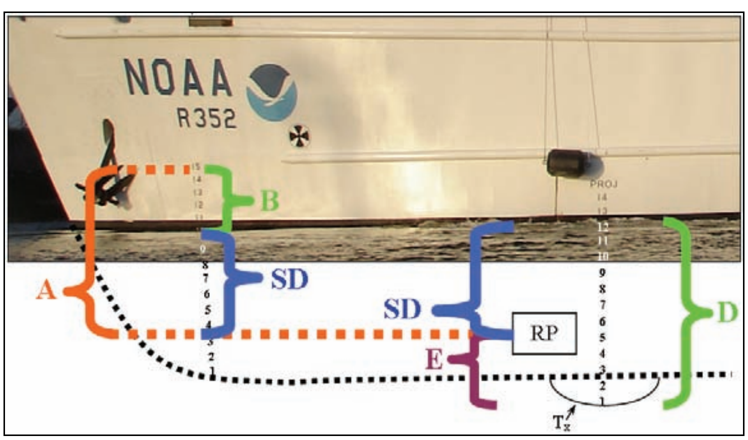


NOTE: The images in figures 1 and 2 are for general reference only. The relative position of components is not true, and the distances are not to scale.

1.2.1.2. Projection and Keel Draft Mark Methods

With the second method, the distance from the base of the 15-foot keel draft mark (a point included in the L3 vessel survey) to the water surface (B) is subtracted from the known distance from the base of the 15-foot draft mark to the granite block (A). With the third method, the static draft of the reference point is calculated by subtracting the transducer-to-granite block vertical offset (E) from the water level according to the projection draft marks (D).

Figure 2: ***Static Draft Determination - Projection & Keel Draft Mark Methods***



A water level was not entered into the EM 1002 installation parameters during the patch test and reference surface portions of the hydrographic systems readiness review trials because static draft had not yet been calculated; the static draft was not measured before leaving port and was not measured while the ship was underway because of unfavorable sea conditions. For the dynamic draft portion of the trials, however, the hydrographer entered into the installation parameters a crude estimate of the water level, -2.11 meters, that was based on a week-old photo of the ship in which the projection draft marks were clearly visible with the ship alongside a pier in very calm water.

Once the ship returned to port, the crude estimate was verified using all three static draft determination methods, the results of which are summarized below in table 1. Interestingly, the average of the three measurements equaled the crude estimate, and the water line was left at -2.11. Refer to Appendix 3 for the static draft determination report.

Table 1: ***Summary of Static Draft Results***

Crude Estimate	*Projection Draft Mark Method*	*Ship's Keel Draft Mark Method*	*Lead Line Method*
-2.11	-2.058	-2.107	-2.178

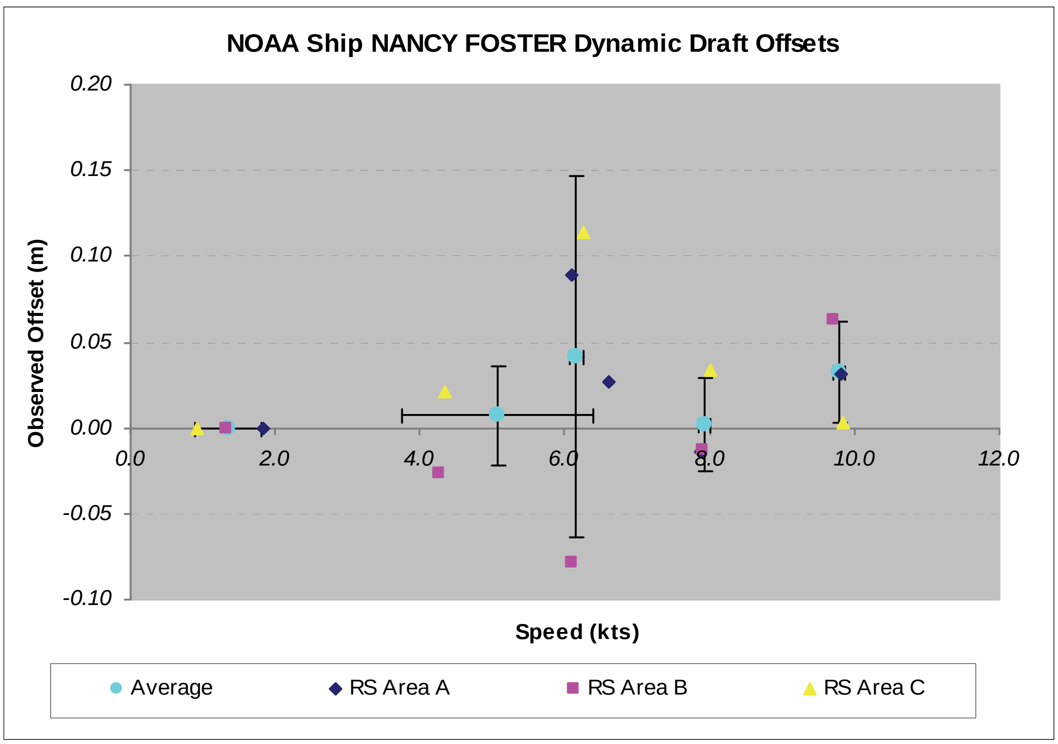
1.2.2. Dynamic Draft

The dynamic draft was determined using the reference surface method as per the Field Procedures Manual. For each of the four selected at-speed RPM levels (790, 1000, 1300, and 1600 on the main engine), data were acquired in both directions to minimize the effects of a slight current. Smaller than the captain's maximum *a priori* estimate of approximately 0.3 meter, the observed delta draft values are negligible, with a maximum corrector of -0.041 meter. The data were processed with preliminary tide zoning and preliminary water levels. The dynamic draft calculations are documented in Appendix 4 and summarized in table 2 and figure 3.

Table 2: ***Tabular Summary of Dynamic Draft Results***

RPM	Area A		Area B		Area C		Average Speed		Average Δ Draft	
	Speed	*Δ Draft*	*Speed*	*Δ Draft*	*Speed*	*Δ Draft*	*Ave.*	*σ*	*Ave.*	*σ*
0	1.832	0.000	1.327	0.000	0.912	0.000	1.357	0.461	0.000	0.000
790	6.598	0.026	4.260	-0.026	4.346	0.022	5.068	1.326	0.007	0.029
1000	6.104	0.088	6.089	-0.078	6.261	0.115	6.151	0.095	0.041	0.105
1300	7.866	-0.015	7.896	-0.012	8.010	0.034	7.924	0.076	0.002	0.027
1600	9.816	0.031	9.696	0.063	9.855	0.004	9.789	0.083	0.032	0.030

Figure 3: ***Graphic Summary of Dynamic Draft Results***



2. HARDWARE SYSTEMS

See Appendix 5 for a preliminary wiring diagram generalizing key survey-related hardware and network components.

2.1. Position, Attitude, and Heading Sensors

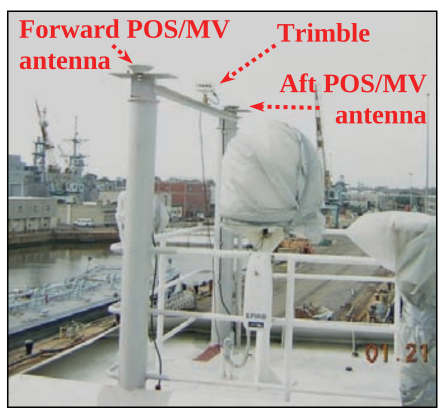
2.1.1. *Applanix 320 POS/MV*

NANCY FOSTER is equipped with an Applanix Model 320 Version 4 POS/MV, with an ancillary Trimble DSM 132 antenna that supplies Coast Guard differential GPS correctors. Whereas the POS/MV is configured via the POS/MV controller software installed on the HYPACK acquisition computer, the Trimble DSM 132 is configured via the controls on the front of the receiver. The system's Inertial Measurement Unit (IMU) is located in the sonar void, within very close proximity of the granite block (see Appendix 2 for the lever arm). The ancillary Trimble DMS 132 antenna is mounted between the primary and secondary POS/MV antennae, which are mounted on the fore and aft ends, respectively, of a mounting bracket installed over the port-side railing of the flying bridge. The IMU and antenna installations are shown in figure 4 and 5, respectively. The two POS/MV antennae and the DMS 132 were not installed on the main mast because the mast vibrates noticeably when the ship is underway.

NOTE: The label on the top surface of the secondary antenna is not orientated so that it points in approximately the same direction as the label on the primary antenna, as is recommended in the POS/MV installation manual. The orientation of the primary antenna and the orientation of the secondary antenna label are offset by approximately 180 degrees.

Figure 4: ***POS/MV IMU and Granite Block Mount***

Figure 5: ***POS/MV & DGPS Antennae Installation***



2.1.1.1. GAMS Calibration

A week prior to the SAT, a visiting Applanix representative performed a successful GAMS calibration. The resulting parameters are shown in the table below.

Table 3: ***Summary of GAMS Calibration Results***

Baseline Vector	
X	**-2.253**
Y	**0.027**
Z	**0.011**
Two-Antenna Separation	
2.253	

The primary antenna-to-granite block and IMU-to-granite block offsets are entered into the POS/MV controller software so that the position output by the POS/MV is the position of the granite block. Also entered into the POS/MV configuration is the granite block-to-center of roll and pitch lever arm. The offset between the granite block and the EM 1002 transducer is accounted for in the EM 1002 installation parameters. For other POS/MV controller parameters, including heave filter settings and serial port settings, refer to Appendix 6, POS/MV Configuration Report. Position and attitude data from the POS/MV are inputted directly at the EM 1002 processing unit (PU).

2.2. Sound Speed Measurement Instruments

2.2.1. SBE 45 Thermosalinograph

NANCY FOSTER is equipped with an SBE 45 Thermosalinograph (TSG). The TSG measures near-surface conductivity and temperature in order to calculate sound velocity, which is input real-time to the partial-curve-array EM 1002's Sun operator workstation to aid in beam-steering. Mounted on the port side of the aft bulkhead of the sonar void, the TSG samples water that is pumped through a system of steel pipes whose intake is located on the hull of the ship approximately 1.3 meters forward of, 0.6 meter to the port of, and 0.7 meter below the TSG. To avoid thermal contamination from the pump, the pump is located on the outflow side of the TSG. A flow-meter is installed near the TSG on the inflow side to monitor the flow rate. See figures 6 and 7 for pictures of the TSG installation.

Figure 6: ***TSG Installation***

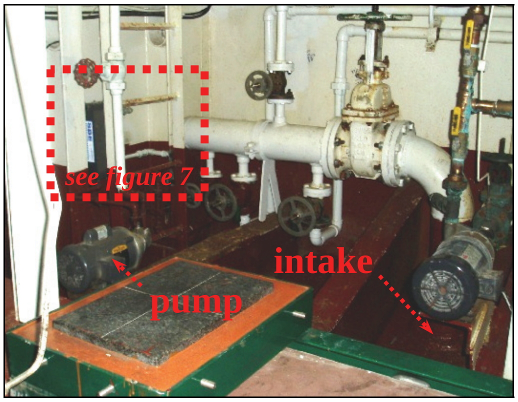
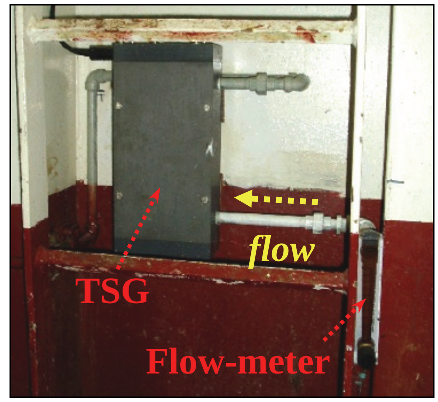


Figure 7: ***TSG and Flow-meter***



NOTE: With the PROM chip currently installed in the TSG processing unit, the TSG, by default, outputs temperature and sound speed data in a format unrecognized by MERLIN. To get the TSG to output the data in the correct format, a user needs to connect the TSG output serial cable to another computer, open a HyperTerminal session (9600 baud), and, while the data string is streaming, type the command "connect45." The user then closes the HyperTerminal session and re-connects the TSG output serial cable to comport 1 of the Solaris box. The ship has a PROM chip replacement that will enable the TSG to output the desired format by default, but it was not installed at the time of the SAT.

2.2.2. Sea-Bird SeaCat SBE19 & SBE19+ CTD Profiler

NANCY FOSTER has the ability to acquire CTD data with either an SBE 19, an SBE19+, or an SBE 911 profiler. Whereas the SBE19 is an archive system, in which CTD data are stored to memory within the unit and then uploaded to a workstation after the cast, the SBE19+ and the SBE911 are real-time systems, in which CTD data are streamed real-time to a shipboard computer via a 0.322" conducting cable. The SBE19 and SBE19+ systems generate a raw hexadecimal file (*.hex), and the SBE911 system generates a raw data file (*.dat). Currently, only the archived SBE19 data and real-time SBE911 are able to be processed by VELOCWIN, as is discussed further in section 3.3, Data Processing Software.

2.3. Manual Depth Measurement Equipment

2.3.1. Lead Line

NANCY FOSTER is equipped with a mahogany-colored tiller-rope lead line that was created the week of February 4, 2006, to serve as a sounding system comparison tool in support of the ship's EM 1002 multibeam operations. The lead line was created as per the procedures documented in *Directions for Creating Traditional Lead Lines and Sounding Poles* (which is excerpted from the NOAA Hydrographic Manual and is included in Appendix 1 of the Field Procedures Manual, v2.1beta), with the exception that orange signal cloth was used to mark every meter rather than straps of leather. Also, due to time constraints, the sub-meter intervals were not marked. Temporary sub-meter markings were made while measuring static draft and performing the sounding system comparison. Permanent sub-meter markings will be made in the future.

2.3.1.1. Sounding System Comparison

A partial sounding system comparison, documented in Appendix 7, was performed as an ancillary part of the SAT while the ship was alongside Pier Papa, Charleston, SC. The intent was to use a lead line to acquire a depth standard and then compare that standard depth to a corresponding simultaneously-logged calculated EM 1002 depth; however, as described on the following page, the results are inconclusive, due to a number of less-than-ideal conditions. NANCY FOSTER was limited to performing the sounding system comparison while alongside the pier because of unfavorable sea conditions while underway.

Illustrated in figures 8, the lead line depth was calculated by measuring the distance from a temporary benchmark (the same temporary benchmark documented in the static draft section) on the lip on the edge of the 02 deck located near the along-ship position of the transducer to the bottom (A) and then subtracting from that distance the distance from the same bench mark to the surface of the water (B), which was measured using the ship's lead line.

Figure 8: ***Sounding System Comparison - Lead Line Depth***

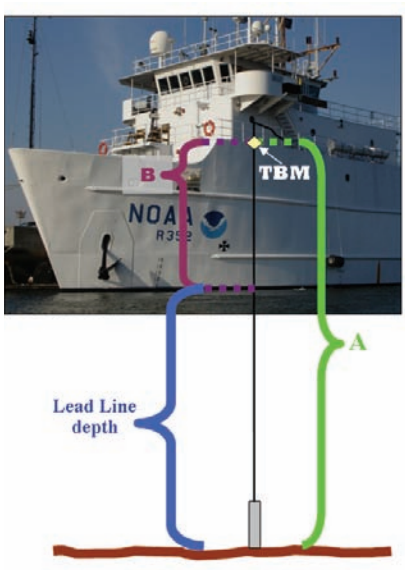
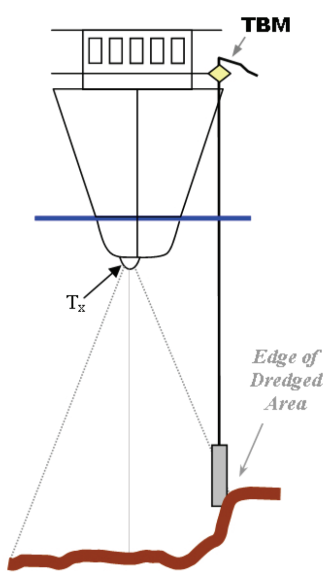


Figure 9: ***Sounding System Comparison - EM 1002 Depth***



Determining which calculated EM 1002 depth to compare against the lead line standard was inconclusive because the lead line measurement was taken directly over an approximately 1.6-meter-high steep slope (see figure 9), which was believed to be the boundary of the dredged area beneath the ship. The hydrographer could not distinguish in the MBES data the slope and what is believed to be the digitized lead line. Although a definitive EM 1002 depth could not be attained, it is clear that the depth is at least between 9.8 meters and 8.3 meters. The lead line depth of 9.155 meters is within this range; however, the lead line measurement itself is somewhat ambiguous because the hydrographer had difficulty determining exactly when the lead hit the bottom, possibly due to the combination of taking the measurement on a slope and in an area with soft sediment. Another possible complicating factor is that, due to the soft-sediment nature of the bottom, the EM 1002 acoustic energy may have penetrated below where it was determined the lead line was hitting the bottom

The OCS liaison recommends that NANCY FOSTER perform, before commencing regular survey operations, another sounding system comparison in an area that is known to be flat and sandy, to minimize any ambiguity in obtaining reliable lead line and EM 1002 depth measurements.

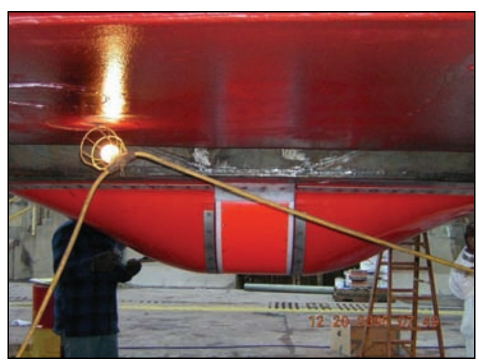
2.4. Multibeam Echosounder (MBES) Systems

2.4.1. Kongsberg EM 1002

NANCY FOSTER is equipped with a hull-mounted Kongsberg EM 1002 multibeam echosounder, which is installed between two fiberglass hydrodynamic fittings near frame 25 (see figures 10 and 11 below). The EM 1002 is a 95-kHz system with a 150° swath consisting of 111 individually-formed 2° beams.

Figure 10: ***Image of EM 1002 Transducer Mount***

Figure 11: ***Image of EM 1002 Transducer Mount Blister***



2.4.1.1. Patch Test

Pitch, roll, yaw, and timing (positioning) biases were estimated by running a series of calibration lines, as described in *Hydrographic Specifications and Deliverables (HSSD)*. Calibration lines were also run to estimate the outer beam angle offset parameter. The patch test portion of the SAT was conducted by Kongsberg representative Chuck Hohing and is documented in the SAT. See table 4 for a summary of the bias estimates.

Using CARIS HIPS's calibration tool, the OCS ship liaison performed an independent estimation of the timing, pitch, and roll biases (documented in Appendix 8) to verify the Kongsberg-derived estimates, which were generated using MERLIN's calibration tool. Although the verification patch test roll bias estimate is comparable to the Kongsberg SAT patch test roll bias estimate, the navigation timing and pitch bias estimates are substantially different.

The OCS ship liaison recommends that NANCY FOSTER performs another timing and pitch bias estimation before commencing regular survey operations.

Table 4: ***Summary of SAT Patch Test Results***

Bias	*SAT Estimates*	*Verification Estimates*
Timing	*0*	*1*
Pitch	*0*	*-1.2*
Roll	*-0.14*	*-0.165*
Gyro	*0*	*See note below*
Outer Beam Roll	*0.39*	*See note below*

A truly independent estimate of the gyro and outer beam angle offset biases could not be performed, because the gyro and outer beam angle offset calibration lines were acquired with the Kongsberg-derived estimate of the roll bias entered into the EM 1002 installation parameters, as per Kongsberg's standard procedure of entering a particular bias estimate into the installation parameters before acquiring the data to estimate the next bias. Since the Kongsberg bathymetry datagram is what gets read into CARIS's observed depth files, the CARIS processed depth data, which are what a CARIS user sees when in calibration mode, are already corrected for whatever bias estimates are entered into the EM 1002 installation parameters. The OCS liaison was able to estimate independently the pitch and roll biases because the Kongsberg timing and pitch estimates happened to be 0.

NOTE: Due to ship scheduling constraints, the EM 1002 multibeam sonar system was not tested at its maximum depth rating of 1000 meters.

In the future, to adhere to the HSSD criterion that corrections shall be applied in such a way that correctors may be easily removed and replaced with a revised set of correctors in post-processing, NANCY FOSTER will correct for timing, pitch, roll, and gyro calibration biases in CARIS, by entering the bias estimates in the appropriate fields within the swath1 sensor of the hvf, rather than accounting for them in MERLIN during acquisition.

NOTE: As discussed in section 1.2.1, Static Draft, the patch test data were acquired without a waterline offset entered in the Merlin installation parameters because the static draft of the transducer had not yet been calculated.

2.4.1.2. Reference Surface

In order to examine the internal consistency of the EM 1002 data, the ship acquired in a 1000 x 1000-meter area a relatively dense data set (approximately 400% coverage), which formed the basis of both qualitative and quantitative analyses. The qualitative analysis consisted of systematically visually examining a 1-m BASE surface created from the high-density sounding set and identifying any possible systematic errors. The quantitative analysis consisted of generating a HIPS 6.0 QC report to statistically compare the point sounding data to a 1-m BASE surface.

The qualitative analysis revealed three systematic errors: (1) an attitude artifact, (2) an artifact attributed to an inadequately estimated outer beam angle offset, and (3) an along-track artifact observed at what is believed to be the shift from phase detection to amplitude detection.

2.4.1.2.1. Attitude Artifact

The attitude artifact, which is illustrated in figures 12 and 13 below, is generally less than 0.3 meter in amplitude and is not considered a significant source of error. The degree to which the artifact is related to roll, pitch, yaw, and/or heave is ambiguous. Along certain portions of certain lines, the artifact appears to be related to roll, as a dip on one side of the swath corresponds to a rise on the opposite side of the swath (figure 12); however, along certain portions of other lines, the artifact appears to be more heave and/or pitch related, as a rise on one side of the swath more or less corresponds to a rise on the opposite side of the swath (figure 13). The SAT team surmised that possible causes include (1) a slight misalignment of the IMU reference frame with respect to the transducer, (2) an unrepresentative heave lever arm, and (3) a combination of 1 and 2. The L3 communications group that surveyed the vessel did indeed survey the center-of-roll-and-pitch lever arm, but they did not document their method; however, the fore-aft component of the surveyed offset is comparable with estimates made by crew members based on general observations.

Figure 12: ***Apparent Roll Artifact (x10)***

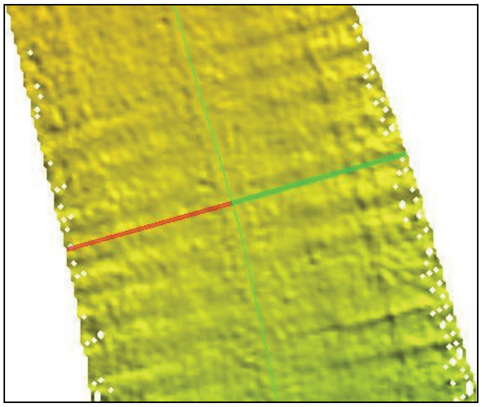
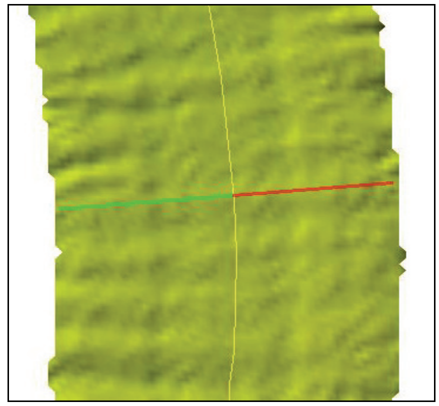


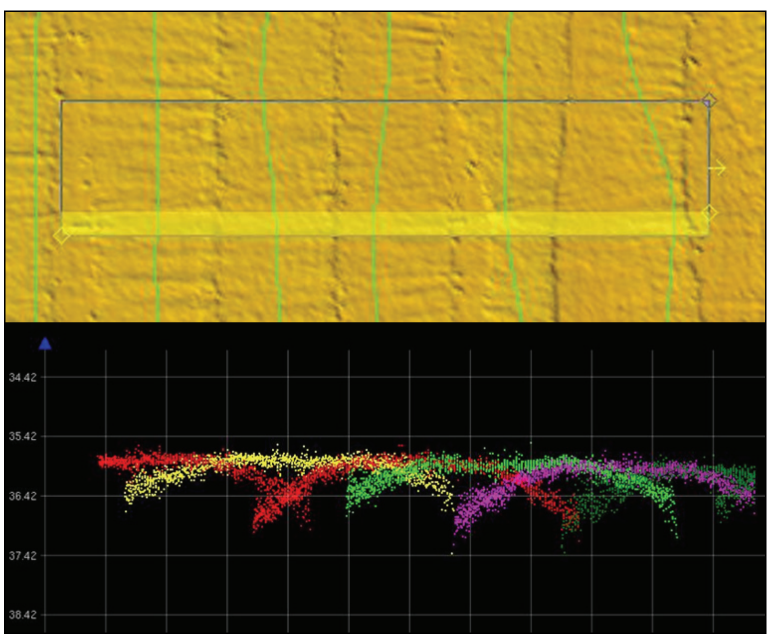
Figure 13: ***Apparent Heave Artifact (x10)***



2.4.1.2.2. Outer Beam Angle Offset Artifact

The outer beam angle offset systematic error was inconsistent throughout the readiness review trials. Immediately after the outer beam angle offset that was calculated as part the patch test was entered into the EM 1002 installation parameters, there was no noticeable artifact; however, in the reference surface dataset, which was acquired the following day approximately 25 nautical miles to the west in 36 meters of water, the artifact measured approximately 1 meter in amplitude, as seen in figure 14.

Figure 14: ***Outer Beam Angle Offset Artifact (x6)***

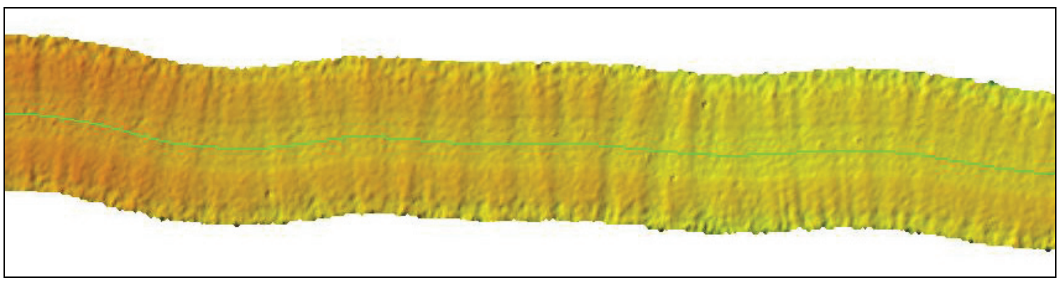


Following the reference surface data acquisition, the Kongsberg representative performed another outer beam angle offset calibration and then entered a new value in the installation parameters. The artifact was negligible throughout the remainder of the readiness review trials. In addition to performing another outer beam angle offset calibration after moving to the new survey area in order to adequately characterize the temperature-dependant value, the operator decreased the angular coverage by up to 15 degrees on either side of nadir to decrease the swath width. See section 3.2, Data Acquisition Software, for a discussion about a calibration file update that is related to the outer beam angle offset.

2.4.1.2.3. Along-track Linear Artifact

The along-track linear artifact that is attributed to the shift from phase detection to amplitude detection, which is illustrated in figure 15 below, is observed in both the bathymetry data and backscatter data. The artifact is deemed an insignificant source of error, as the vertical offset between data on either side of the artifact is less than 0.2 meters.

Figure 15: ***Along-track Linear Artifact (x10)***



2.4.1.2.4. Quality Control Report

The quantitative analysis shows that within the reference surface dataset, which was examined for gross flyers and noise, 36 of the system's 111 beams (beams 1-17 and 93-111) are not within IHO order 1 specifications; however, the validity of these results should be viewed with caution, as the CARIS QC tool compares individual HDCS soundings from crosslines to a mainscheme BASE surface rather than comparing a *BASE surface* generated from crossline data to a mainscheme BASE surface. Also important to note is that the reference surface data were acquired with the EM 1002 swath angle set to its maximum value, 75° on either side of nadir, and that there was a noticeable outer beam angle offset artifact in the dataset. Following the reference surface data acquisition, as previously mentioned, NANCY FOSTER decreased the swath angle to negate the influence of the less reliable outer beam angles. See Appendix 9 for the HIPS QC report.

2.5. Side Scan Sonar (SSS) Systems

Although NANCY FOSTER does not have a permanent SSS system, the ship does have a 22,000-lb-maximum-load moveable A-frame and a 6000-lb-maximum-pull Oceanographic winch that are capable of supporting SSS operations. Individual science parties are responsible for supplying and configuring any other hardware and software.

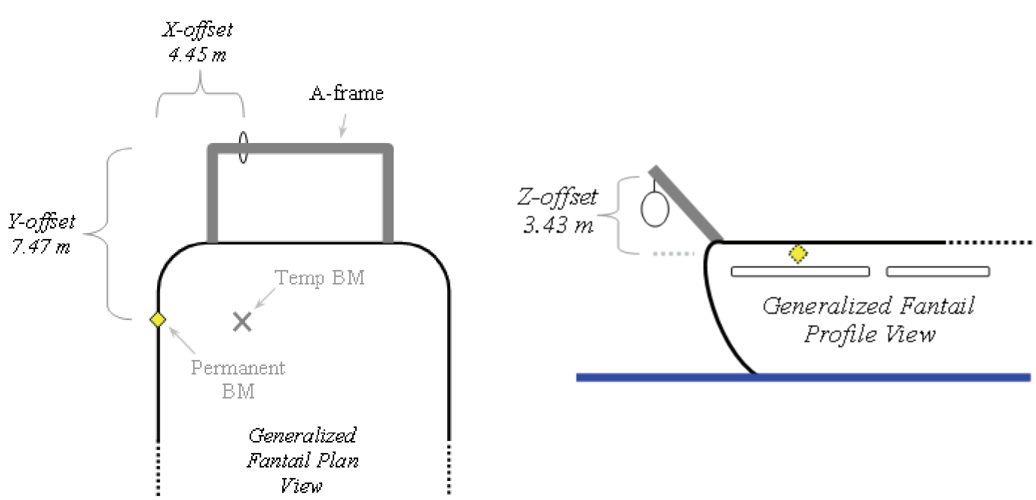
The tow-point (TP) of the SSS A-frame was not surveyed as part of the L3 Communications vessel survey; however, the OCS representatives tied the RP-to-tow-point lever arm into the ship vessel coordinate system by measuring the x and y offsets of the tow-point from a known benchmark near the SSS A-frame (see figure 16). The z component of the lever arm was based on a schematic of the A-frame installation. The calculations are summarized in table 5 and are documented in Appendix 10.

Table 5: ***Sidescan Sonar Tow Point Lever Arm***

Offset	*RP-to-alignment cube (meters)*	*Alignment cube-to-TP (meters)*	RP-to-TP (meters)
x	5.817	-4.45	1.367
y	-35.945	-7.47	-43.415
z	-4.712	-3.43	*See note below*

NOTE: In CARIS, the z-component of the RP-to-TP lever arm is the vertical distance from the towpoint to the water surface, not the vertical distance from the towpoint to the reference point; the z-component of the RP-to-TP lever is dependent on the waterline.

Figure 16: ***Alignment Cube-to-Sidescan Sonar Tow Point Lever Arm***



3. SOFTWARE SYSTEMS

3.1. Computer Operating Systems

NANCY FOSTER has four computers that are dedicated for multibeam operations: a navigation/line steering computer running Windows 2000, a CTD processing computer and a MBES data processing computer running Windows XP professional, and an MBES data acquisition Sun workstation running Solaris. Refer to the software section of the hydrographic systems inventory in Appendix 11 for computer specifications.

3.1.1. Network Configuration Concerns

During the SAT, MBES data were logged locally and were transferred to the processing workstation via an ftp profile configured in a Hummingbird environment installed on the processing workstation; however, transferring data from the Unix-based acquisition computer to the windows-based processing computer via this ftp profile was very burdensome because the IP address of the processing computer had to be changed to match the IP group (157.237.15.#) of the acquisition computer network card prior to data transfer and then reconfigured to receive a shipboard-network IP (group 10.48.2.#) via DHCP (because only one of the acquisition computer’s two network cards was functioning). In addition to changing the processing computer’s IP address, the user had to unplug the EM 1002 PU network cable from the topside acquisition computer and then plug in a shipboard network cable in order to transfer files from the acquisition computer; after transferring files, the user then needed to unplug the shipboard network cable from the acquisition computer and re-connect the PU network cable. Although this less-than-ideal, convoluted procedure worked, there were the concerns that (1) the user needed to log on to the acquisition computer via ftp with a user account that had administrative privileges and (2) the EM 1002 PU had to be rebooted every time after reestablishing its network connection.

The SAT team initially considered using NOAA Ship THOMAS JEFFERSON’s old EM 1002 Unix acquisition computer, which has two network cards, in order to circumvent the data transfer issues, but in favor of performing the SAT with what is intended to be the ship’s permanent system, the team, with guidance from Chief of HSTP, decided to use the newer system, even though it had only one network card.

Following the SAT trials, however, in favor of a more streamlined file management/transfer procedure and to minimize the number of EM 1002 PU reboots, NANCY FOSTER survey personnel, under EED guidance, swapped out the new acquisition computer with NOAA Ship THOMAS JEFFERSON's old Unix EM 1002 acquisition computer. Just as with the previous configuration, a user accesses files on the acquisition computer via an ftp profile configured in a Hummingbird environment on the processing computer; however, because the older computer has two functioning network cards, network cables do not have to be swapped before and after transferring files from the acquisition computer and the EM 1002 PU power does not need to be recycled after every data transfer. The ship will operate with the older acquisition computer until such a time that the second network card on the new acquisition computer is operational.

NOTE: ASVP files are also uploaded to the acquisition computer from the processing computer via a Hummingbird ftp profile; however, whereas a user logs on as "em1002" to transfer data from the acquisition computer to the MBES data Maxtor hard drive, a user logs on as "root" when transferring the sound velocity file to the acquisition computer. Unlike the "em1002" user profile, the "root" user profile allows a user to copy files to the acquisition computer hard drive.

3.2. Data Acquisition Software

The Unix-based MBES acquisition computer is loaded with Kongsberg's MERLIN, version 5.2.2. The SAT calibration bias estimates (including the outer beam roll coefficient), the IMU-to-transducer lever arm, and the water level were entered into the software installation parameters, which are documented in appendix 11. For line steering, HYPACK is installed on a computer in the dry lab, with the helm's display repeated on the bridge. See Appendix 12 for a report detailing the MERLIN installation parameters, and Appendix 13 for a report detailing the HYPACK device model configurations.

3.2.1. Updated Sonar Calibration File

Following acquisition of the reference surface dataset, because there was a conspicuous outer beam angle offset artifact, the Kongsberg representative uploaded to the system's processing unit (PU) an update to the EM 1002 transducer's calibration file. Following the calibration file update, however, the system failed the *BSP* BIST programs. Because of this BIST failure following the installation of the transducer calibration update file, the Kongsberg representative also uploaded to the PU four updated files (c44a.out, c44d.out, c44x.out, and c50.out) that had been shipped back with the BSB board (#349816) a week prior, after the BSP board had been sent to Kongsberg two weeks earlier following an earlier failure of the board during the system's Harbor Acceptance Test (HAT).

3.3. Data Processing Software

The Windows-based processing computer is loaded with CARIS HIPS & SIPS 6.0, which is configured to use a local single user USB key. The NOAA hydrographer created a HIPS vessel file (hvf) containing appropriate entries, including uncertainty estimates for a number of the fields in the "TPE" section. To account for situations when svp data are to be applied to the EM 1002 data during post-processing in CARIS, the granite block-to-transducer lever arm was entered into the svp1 sensor of the hvf as per CARIS technical note *Sound Velocity Corrections for Simrad EM 1002 Data*. See Appendix 14 for the vessel hvf report and an explanation of the uncertainty estimates.

Also installed on the processing workstation is VELOCWIN, version 8.80, which is used to generate, from an SBE19 *.hex file, an *.asvp file, which is an ASCII depth-versus-sound speed file in a format recognized by MERLIN, Kongsberg's acquisition program. After the cast is extended in MERLIN's SVP Editor, these *.asvp files are loaded into MERLIN's runtime parameters prior to acquisition, for real-time sound velocity correction. VELOCWIN was not installed in the computer that is currently used to process CTD data because of a SEATERM version conflict with the ship's real-time SBE19+ system. Whereas the ship would like to run an up-to-date version of SEATERM for its SBE19+ operations, VELOCWIN requires the older version 1.30.

NOTE: As is mentioned in section 2.2, Sound Speed Measurement Instruments, VELOCWIN is currently unable to process data from the real-time SBE19+ system. The OCS ship liaison, however, has contacted HSTP to investigate the possibility of modifying VELOCWIN so that it can also process the real-time SBE19+ data.

3.4. Support Software

NANCY FOSTER is equipped with a number of supporting software programs that are useful for survey planning, troubleshooting, and data presentation. Among the supporting programs are NOAA Chart Reprojector, Planning (Trimble's GPS planning software), and Corpscon. GeoZui will the installed at a later date.

4. HYDROGRAPHIC PERSONNEL

In addition to the commanding officer, NANCY FOSTER has two crewmembers whose normal duties include responsibility for activities that directly affect survey planning, data acquisition, and data processing: the field operations officer and a survey technician. Refer to the hydrographic systems inventory in Appendix 11 for a roster of hydrographic personnel.

Appendix 1: *Sea Acceptance Test (SAT) Report*

Product/Project:

EM 1002
Multibeam Echo Sounder

Document title:

Sea Acceptance Test (SAT)

J					
I					
H					
G					
F					
E					
D					
C					
B					
A	28 Jan 2002	USA version			
Rev.	Issue date	Reason for issue	Made	Checked	Approved

Project no:	Contract identification:	Customer document number:
Archive no:		Registration no: USA: P/N 839-121252

NOAA
NANCY FOSTER

Date 6MAR06-10MAR06

Kongsberg Underwater Technology, Inc.
Lynnwood, WA 98036-4707

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EM 1002 SEA ACCEPTANCE TEST

1. INTRODUCTION

The purpose of this procedure is to verify that the system as installed is fully functional at sea and to serve as a record of the successful completion of the Sea Acceptance Test (SAT). It is to be used to verify correct functioning of the multibeam echo sounder and the various external sensors or systems as an integrated mapping system. It will also verify that the system interfaces and peripherals are functional

The sea trials shall establish that the:

- EM 1002 unit works properly at sea
- heave, roll and pitch signals are correctly used
- heading signal is correctly used
- sound speed input data are correctly used
- positioning system data are correctly used
- system is capable of providing consistent depth data
- system during operation produces digital data to its internal storage devices and, if available, to an external logging system connected via Ethernet

The Sea Acceptance Test shall consist of a verification of correct interfacing of external sensors, a calibration of external sensor offsets and time delays, a test survey, and assessment of the data from the test survey. In addition, as far as time and external conditions allow, limitations on system performance as a function of water depth, vessel speed and sea state shall be established.

2. REFERENCES

Factory and Harbor Acceptance Test records

3. TEST EQUIPMENT

No special test equipment is required for the Sea Acceptance Test, but all sensors normally needed for surveying with a multibeam echo sounder shall be available.

4. LIST OF ITEMS

The following items are to be tested during the SAT. Any replacement modules or circuit boards since the HAT must be noted.

List of Items to Be Tested		
Item	Manufacturer, type and/or reg. number	Equipment
1a	S/N 303	EM 1002 Transceiver Unit
1b	SUN S/N TT32220431	EM 1002 Operator Station
1c	288	EM 1002 Transducer
2a	POS/MV 320 V4 IMU S/N: 447 PCS S/N: 2249	Motion Sensor No 1
2b	N/A	Motion Sensor No 2
2c	POS/MV 320 V4	Heading Sensor
3	SBE 45 MICRO TSG	Fixed Sound Speed Sensor S/N 4540569 - 0155
4	SEABIRD SBE 19	Profile Sound Speed Sensor
5		
6		
7		
8		

5. CONFIGURATION

The transducer and circuit boards included in the system and their serial numbers were noted in the Factory and Harbor Acceptance Tests. Any replacement modules or circuit boards since the HAT must be noted.

Replacement List			
Item	Equipment	Registration number	Serial number
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

The system software version must be noted, including those of the subsystems, and reflecting any changes made during the trials:

Software Version			
Item	Software	Version number	Version date
1	Workstation software	SUN SOLARIS 8	
2	Simrad software	5.2.2	06.11.2003

Select the Installation Menu on the workstation. The menu sets standard parameters given by the physical installation of the system. Record the current system configuration on the ship.

EM 1002 Position Offsets (All Locations in Meters)			
	Forward (x)	Stbd (y)	Downward (z)
Position Port 1			
Position Port 3			
Position Port 4			
Position Ethernet			
Transducer	0.81	1.86	1.68
Motion Sensor 1			
Motion Sensor 2			
Transducer Installation Angles			
Heading (deg)	0.03		
Roll (deg)	− 0.01		
Pitch (deg)	0.05		
Motion Sensor			
Sensor Delay (ms)	0		
Roll Offset (deg)			
Pitch Offset (deg)			
Heading Offset (deg)			
Roll Reference Plane	ROTATION POS MV		

LEVER ARMS + MOUNTING ANGLES ENTERED IN POS/MV

REF TO IMU LEVERARM
X 0.737 m
Y 0.001 m
Z -0.125 m

REF TO PRIMARY GPS LEVERARM
X 6.571 m
Y -4.740 m
Z -16.308 m

IMU FRAME W.r.t. REFFRAME
X -0.009 deg
Y -0.006 deg
Z - 0.057 deg

REF TO CENTER OF ROTATION LEVERARM
X -12.295
Y 0.000
Z -1.965

6. INTERCONNECTION ARRANGEMENT

The system shall have been installed according to the Installation Manual and passed the Harbor Acceptance Test.

7. TEST PROCEDURE

The test will be documented through the tables on the following pages. The tests shall generally be done in the following order:

1. Interface tests
2. Calibration
3. Survey
4. Noise and sea state performance assessment
5. Assessment of the survey data collected should preferably be done on board.

Note that the check list, noise measurements and test of performance with regard to depth and sea state are to be run in the order which best suits the conditions during the test period. It is not expected that many different conditions will be encountered during the limited time available for the Sea Acceptance Test. However, it is strongly advised that as different conditions are encountered during later use of the system, the system performance as a function of external conditions be noted. This will be valuable for later use in survey planning and in ensuring the most efficient use of the system.

7.1 Test of interfaces

Tests of the external sensor interfaces should have been run during the Harbor Acceptance Test. However, these tests were necessarily limited (static only), and may not even have been done due to non-availability or non-functionality of external sensors. Thus the data from the external sensors should be observed on the system display during vessel maneuvering, and verified for correctness (positions and clock) or correct sign and/or reasonable magnitude (heave, roll, pitch, heading and sound speed).

During the test data will be logged, all connected hard-copy devices should be employed, and sound speed profiles loaded into the system. Observe that this is functional. Fill in the table below to record this:

Test no.	Function to Be Tested	Test Result	Notes
1	Position input	ok	
2	External clock input	ok	CLOCK DIFF PU-ZDA 0-1 ms
3	Transducer depth sound speed input	ok	
4	Sound speed profile input	ok	LOADED VIA FLOPPY
5	Heading input	ok	
6	Motion data input	ok	
7	Data output to internal storage	ok	
8	Data output to external Ethernet	ok	FTP DATA TO EXTERNAL COMPUTER
9	Printer/plotter/recorder output	N/A	

7.2 Sensor offset/calibration

If at all possible the offset or zero bias of the roll, pitch and heading sensors and the time delay of the positioning system(s) should be measured or estimated before leaving port (this is especially important with regard to the heading sensor). A calibration of these offsets shall be performed at sea as the second part of the test in accordance with the procedures given in the Operator Manual. Finally, these offsets shall be estimated from the final test survey. Fill in the table below with the offsets as entered into the Operator Station:

	Port Estimate	Calibration Result	Final Results
Roll offset		-0.14	-0.14
Pitch offset		0	0
Heading offset		0	0
Position time delay	0	0	0
Outer beam angle offset	N/A	0.39 / -0.18	0.39 / -0.18

RESULT AFTER ADDING CALIB. TXT

Note the positioning system type(s) used during the Sea Acceptance Test and its estimated accuracy:

Positioning system no 1	POS/MV 320 V4
Estimated accuracy for position system	

Positioning system no 2	N/A
Estimated accuracy for position system	

Positioning system no 3	N/A
Estimated accuracy for position system	

7.3 Survey

The integrity of the total survey system consisting of the multibeam echo sounder as installed on the vessel, motion sensor, heading sensor, sound speed sensor(s), and positioning system(s) shall be assessed by doing a survey of a limited area and evaluating the collected data. The result should be compared against the specified accuracy of the echo sounder, taking into account the precision of the external sensors, and any limitations imposed by the vessel and its handling. Note that this test is **not** designed to measure the accuracy of the echo sounder itself, as this would require a much more extensive test period, and has been done on previous system installations.

The sea acceptance test's main part will be a sensor calibration followed by a system assessment survey in the calibration area. The area used for the sea trials should thus consist at least partly of a relatively flat bottom and partly of a significant slope as required for a calibration in accordance with the guidelines for calibration as given in the Operator Manual. In case this is not possible the calibration of the various sensors must be run in separate areas while the final assessment survey should be run in the flat part used for roll calibration. The depth should then ideally be in the 10-140 m range (not critical).

Five parallel lines should be run with a line spacing equal to about one quarter of the achieved coverage in the actual area. Neighboring lines should be run in opposite directions. The line length should be in the order of twice the achieved coverage. A sixth line should be run perpendicular to and across the five previous lines.

Assess the data with the system's grid display using a grid cell size giving about 10-20 soundings per cell. Using the various display options, investigate the frequency and magnitude of outliers, discrepancies between lines, and depth differences within cells. Use also the calibration profile displays to assess any remaining errors due to roll offset or sound speed profile problems. If the performance of the system is not according to expectation, describe the results in the Comment section below; otherwise note that the system performance is accepted. Any irresolvable performance problems should be further investigated and quantified with a postprocessing system such as Neptune from Kongsberg Simrad.

Note the area with position and depth where the Sea Acceptance Test has been performed:

SAT area	REFERENCE SURFACE CHARLESTON, SC
SAT position	N 32.44 79.21 W
SAT depth	36 m

7.4 Noise and sea state performance assessment

During the sea acceptance test, the performance of the whole system shall be assessed. The important factors limiting achievable accuracy and coverage are noise (vessel and environmental) and sea state. With heavy seas it is to be expected that the performance will also depend upon vessel heading with respect to wave direction. It is recommended to assess noise level and achieved coverage as a function of environmental parameters both during the sea acceptance test and later operation. The results should be entered in the table below, both to document conditions during the test and later to have a record of the system's performance according to external conditions.

The noise experienced by the system may be measured from the Operator Station as described in the Operator Manual. Several measurements should be taken and the result averaged before noting it in the table below:

Date	Depth (M)	Sea State	Heading Against Waves	Speed	RPM	Noise Level	Comments
03/07 2006	33m	4-6'	015	6.4	1270	60	HEAVY WEATHER, A LOT OF MOTION
03/07 2006	36m	4-6'	WAVES ASTERN	6.0	900	51	
03/07 2006	54m	2'-4'	INTO SEAS	5.2	1180	52	
03/08 2006	66m	3'	INTO SEAS	4	970	49	WINDS NE 10-15KTS
3/09 2006	36m	2-3'	–	0	790	48	SWELLS FROM 185°
03/09 2006	33m	1'-2'	FOLLOWING SEAS	7	1120	55	
03/09 2006	33m	1'-2'	FOLLOWING SEAS	10.9	1600	62	
03/09 2006	20m	1'-2'	–	6.0	1000	51	CLEAN DATA

The coverage is assessed by observing the swath width on the Operator Station on a reasonably flat bottom. The average of several pings and any occurrence of missed pings should be noted in the table below:

Date	Depth (M)	Sea State	Heading Against Waves	Speed (Kn)	RPM	Mode	Coverage (M)	Missing Pings, Comments
03/07 2006	33	4'-6'	015	6.8	1270	SHALLOW	88/95	LOST BEAMS, MISSING PINGS WHEN HEAVE ~ 2M
03/07 2006	36	4'-6'	WAVES ASTERN	6.0	900	SHALLOW	95/102	NO LOST BEAMS HEAVE MUCH LOWER
03/08 2006	36	1-2		5.0		SHALLOW	96/99	DATA SOLID
03/09 2006	33	1'-2'	FOLLOWING SEA	7.0	1120	SHALLOW	112/113	
03/09 2006	20.8	1'-2'	FOLLOWING SEA	5.2		SHALLOW	47/50	DATA GOOD

8. ACCEPTANCE

The SEA ACCEPTANCE TEST for the EM 1002 for NOAA SHIP NANCY FOSTER has been performed according to this test procedure.

Remarks: A CALIB.TXT FILE WAS DOWNLOADED TO THE TRANSCEIVER PU. WITHOUT THIS FILE INITIAL OUTER BEAM ANGLE OFFSET WAS 0.39. WITH THE FILE OUTER BEAM ANGLE OFFSET NOW ~0.18.
FOUR FILES (C44A.OUT, C44D.OUT, C44X.OUT, C50.OUT) WERE DOWNLOADED TO THE TRANSCEIVER PU TO FIX BSP ERROR DURING BIST. THE OLD FILES WERE REMOVED.
BSP S/N 349816 WAS INSTALLED PRIOR TO THE SAT AND THE SYSTEM BIST CHECKED OK. THIS BSP WAS SENT IN FOR ~~REPAIR~~ testing AFTER THE HAT & then returned with the four files mentioned above files were installed. See set files above.
VOLTAGE TO THE TRANSCEIVER WAS CHECKED (237 VAC).

The test is accepted / not accepted (circle one).

Test performed by: Chuck Hohing

Print name: CHUCK HOHING

Position: FIELD ENGINEER

Date: 03/09/06

Test witnessed by: Thanh Loi + Names below

Print name: Thanh Loi

Position: Electronics Engineer

Date: 03/10/06

witnesses:
Nick TORFINSKI — ATLANTIC HYDROGRAPHIC Branch (AHB)
SHAWN MADDOCK — HYDROGRAPHIC System Technology program (HSTP)
DAN BOIES - ST
MIKE Staelcher - Tim Battista's Contractor

Appendix 2: *Vessel Static Offset Survey Report*

ENCLOSURE 1

L3 communications
Power & Control Systems Group
PacOrd

PacOrd
Jacksonville Division
3161-3 St. Johns Bluff
Jacksonville, FL 32246
Phone:(904) 641-5442
Fax: (904) 641-9967

SYSTEM	All readings are in centimeters					All readings are in Degrees					
	Horiz			Vert		Heading		Pitch		Roll	
	X	Y		Z		Degrees		Degrees		Degrees	
Granite Block	0.0	0.0		0.0		0.0000	±0.1°	-0.0022	±0.0025°	0.0014	±0.0025°
IMU Foundation	73.7	0.1	±0.5cm	4.3	±0.5cm	0.0573	±0.1°	0.0061	±0.01°	0.0092	±0.01°
IMU Top Surface	73.7	0.1	±0.5cm	-12.5	±0.5cm	0.0573	±0.1°	0.0061	±0.01°	0.0092	±0.01°
AFT POS/MV Antenna #2	430.9	-473.7	±0.5cm	-1628.2	±0.5cm	N/A		N/A		N/A	
FWD POS/MV Antenna #1	657.1	-474.0	±0.5cm	-1630.8	±0.5cm	N/A		N/A		N/A	
POS/MV Antenna rel. to each other	226.2	-0.3	±0.5cm	N/A	-	N/A	-	N/A	-	N/A	-
Center of Roll and Pitch	-1229.5	0.0	±5cm	-196.5	±5cm	NA	-	NA	-	NA	-
Ship' Draft Marks Aft Stbd	-3138.5	609.6	±5cm	-289.4	±2cm	NA	-	NA	-	NA	-
Ship' Draft Marks Aft Port	-3138.5	-609.6	±5cm	-289.4	±2cm	NA	-	NA	-	NA	-
Ship' Draft Marks Fwd Stbd	1071.7	350.5	±5cm	-350.4	±2cm	NA	-	NA	-	NA	-
Ship' Draft Marks Fwd Port	1071.7	-350.5	±5cm	-350.4	±2cm	NA	-	NA	-	NA	-
Port Gyro	216.5	0.0	±5cm	-1254.8	±2cm	0.0017	±0.25°	NA	-	NA	-
Stbd Gyro	216.5	43.2	±5cm	-1254.8	±2cm	0.0047	±0.25°	NA	-	NA	-
EM 1002 Multibeam Foundation (Bottom)	81.1	185.6	±1cm	153.7	±1cm	0.0286	±0.1°	0.0500	±0.025°	-0.0139	±0.025°
EM 1002 Multibeam	81.1	185.6	±1cm	167.6	±1cm	0.0286	±0.1°	0.0500	±0.1°	-0.0139	±0.1°
ADCP	-665.5	-157.8	±5cm	154.6	±2cm	45.0750	±0.25°	-0.0750	±0.25°	0.0167	±0.25°
AFT Deck Bench Mark Port	-3783.7	-527.1	±0.5cm	-386.1	±0.5cm	0.0000	±0.1°	NA	±0.05°	NA	±0.05°
AFT Deck Bench Mark Stbd	-3783.7	527.1	±0.5cm	-386.1	±0.5cm	0.0000	±0.1°	NA	±0.05°	NA	±0.05°
AFT Deck Alignment Cube	-3594.5	581.7	±0.5cm	-471.2	±0.5cm	0.0000	±0.1°	0.0555	±0.01°	-0.0083	±0.01°
Moon Pool BM	-2197.7	121.9	±0.5cm	-385.4	±0.5cm	0.0000	±0.1°	NA	±0.05°	NA	±0.05°
Flying Bridge Port BM	469.9	-559.4	±0.5cm	-1419.9	±0.5cm	0.0000	±0.1°	NA	±0.05°	NA	±0.05°
Flying Bridge Stbd BM	469.2	561.4	±0.5cm	-1418.6	±0.5cm	0.0000	±0.1°	NA	±0.05°	NA	±0.05°
Flying Bridge Alignment Cube	648.3	2.5	±0.5cm	-1431.2	±0.5cm	0.0000	±0.1°	0.0333	±0.01°	-0.0333	±0.01°
Dry Lab Fwd Bench Mark	-462.6	313.5	±0.5cm	-589.0	±0.5cm	0.0000	±0.1°	NA	±0.05°	NA	±0.05°
Dry Lab Aft Bench Mark	-993.2	313.5	±0.5cm	-589.4	±0.5cm	0.0000	±0.1°	NA	±0.05°	NA	±0.05°
Dry Lab Alignment Cube	-639.3	102.9	±0.5cm	-588.7	±0.5cm	0.0000	±0.1°	0.0500	±0.01°	0.0083	±0.01°
Computer Lab Fwd Bench Mark	-600.4	-380.9	±0.5cm	-596.7	±0.5cm	0.0667	±0.1°	NA	±0.05°	NA	±0.05°
Computer Lab Aft Bench Mark	-1070.2	-380.8	±0.5cm	-597.8	±0.5cm	0.0667	±0.1°	NA	±0.05°	NA	±0.05°
Computer Lab Alignment Cube	-837.9	-162.2	±0.5cm	-569.7	±0.5cm	0.0000	±0.1°	0.0042	±0.01°	0.0167	±0.01°
IMU AFT Bench Mark	-146.9	16.6	±0.5cm	-19.7	±0.5cm	0.0000	±0.1°	NA	±0.05°	NA	±0.05°

IMU FWD Bench Mark	339.0	17.4	±0.5cm	-19.5	±0.5cm	0.0000	±0.1°	NA	±0.05°	NA	±0.05°	
IMU Alignment Cube	161.1	169.2	±0.5cm	-4.4	±0.5cm	0.0000	±0.1°	-0.0111	±0.01°	-0.0528	±0.01°	
ADCP AFT Bench Mark	-1169.8	-26.7	±0.5cm	-38.4	±0.5cm	0.0000	±0.1°	NA	±0.05°	NA	±0.05°	
ADCP FWD Bench Mark	-148.7	-26.7	±0.5cm	-38.4	±0.5cm	0.0000	±0.1°	NA	±0.05°	NA	±0.05°	
ADCP Alignment Cube	-668.5	-208.0	±0.5cm	18.4	±0.5cm	0.0000	±0.1°	0.0389	±0.01°	0.0444	±0.01°	
Gyro Bench Mark Fwd	216.5	22.4	±0.5cm	-1164.5	±0.5cm	0.0000	±0.1°	NA	±0.05°	NA	±0.05°	
Gyro Bench Mark Aft	-98.5	22.4	±0.5cm	-1156.9	±0.5cm	0.0000	±0.1°	NA	±0.05°	NA	±0.05°	
Keel Bench Mark Fwd	318.6	1.9	±0.5cm	108.3	±0.5cm	0.0000	±0.1°	NA	±0.05°	NA	±0.05°	
Keel Bench Mark Aft	-118.3	1.9	±0.5cm	108.3	±0.5cm	0.0000	±0.1°	NA	±0.05°	NA	±0.05°	
12Khz Stbd	-634.4	-157.8	±5cm	154.6	±2cm	N/A	-	0.3167	±0.25°	-0.1167	±0.25°	
200KHZ Transducer	-236.7	-90.2	±5cm	108.3	±2cm	N/A	-	0.0917	±0.25°	-0.0333	±0.25°	
Moon Pool Adapter	-2248.7	121.3	±5cm	111.8	±2cm	N/A	-	-0.0250	±0.25°	0.1500	±0.25°	

Port Down = Positive

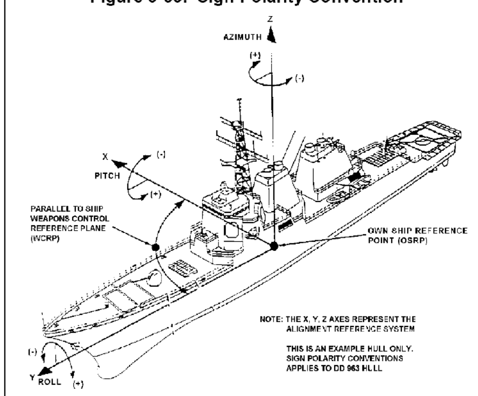
Bow Down = Positive

X dimension readings forward of Granite Block = positive, aft of Granite Block =negative

Y dimension readings starboard of Granite Block = positive, port of Granite Block =negative

Z dimension readings lower than Granite Block = positive, higher than Granite Block =negative

Figure 3-53. Sign Polarity Convention



communications
Power & Control Systems Group
PacOrd

2/8/2006

Subj : NOAA SHIP Nancy Foster Survey

Ref: (a) SW225-AO-MMA-010/OP762/ALIGN THEORY, Theory of Combat System Alignment
(b) Table 1 of ITEM NO. 501

Encl: (1) Foundation Leveling Data Sheets

PacOrd personnel accomplished the survey of the equipment listed in table 1 of work item # 501 on board the NOAA SHIP Nancy Foster.

The granite blocks Roll and Pitch planes were set to the ship's gravity plane. The granite block was then used as the reference for all readings requiring a comparison to the ship's gravity plane.

The ship's centerline was transferred up from the keel, to the granite block 0°-180° reference line through an access cut into the hull of the ship. The granite block reference lines were then used as the reference for all readings requiring centerline reference.

The IMU foundation had to be removed, drilled and tapped for the new style IMU and reset.

The 12KHZ Transducer pitch angle exceeds the ±0.25° allowed by four minutes (reading is +0.3166°), a waiver was received from NOAA for this condition.

All other readings are within tolerance.

The final survey data is summarized in enclosure (1).

Byron K. Dunn
CSA Engineer

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(904) 641-5442 - Phone
(904) 641-9967 - Fax

L3 communications

PacOrd

INSPECTION/DEFICIENCY REPORT

SERIAL NO.	00656.001.02-03
JOB ORDER NO.	

VESSEL NAME		DATE SUBMITTED
NOAA SHIP NANCY FOSTER		7-Feb-06
WORK ITEM NO. 501	PARAGRAPH para. 7.5	INSPECTION DATE(S) 11/14/05-02/02/06

TITLE OF WORK ITEM
SURVEY

TYPE OF REPORT
NOTICE
BALANCE REPORT

☐ IDR/CFR ☒ REQ REPORT ☐ PCP ☐ INFO ONLY ☐ OTHER

☐ PRINTS/DWG ☐ CFM/CFE ☐ GFM/GFE ☐ CONFLICTING PRINTS/DWGS SUPPLIED

☐ PRINTS/DWGS DO NOT REFLECT EXISTING SHIPBOARD / SITE CONDITIONS; DWG. NO:

incorrect: ☐ SPECIFICATIONS ☐ COMPARTMENT ☐ LOCATION REFERENCED SYSTEM:

PROBLEM/CONDITION:

Contractor accomplished Alignment Survey.
See attached results.

RECOMMEND: ☐ ISSUE A CHANGE ORDER ☒ ACCEPT REQUIRED REPORT ☐ ACCEPT PCP ☐ ACCEPT INFO ☒ SEE ATTACHED

Recommend Supervisor accept required report.

LEAD SHOP/AFFECTED TRADES	SIGNATURE OF ORIGINATOR	PRINT NAME	DATE
PacOrd	Byron K Dunn	Byron K. Dunn	7-Feb-06

PROGRAM MANAGER/PROJECT SUPERINTENDENT DIRECTIONS

THE ABOVE RECOMMENDATIONS NEED TO BE CONTRACTUALLY INVOKED WITHIN DAYS OF ## TO LIMIT PRODUCTION IMPACT

☐ THIS REPORT EFFECTS CRITICAL PATH ☐ CHARGED TO BASIC ☐ CHANGE TO BE ISSUED ☐ AUTHORIZED TO PROCEED

CUSTOMER /SUPSHIP FINDINGS, RECOMMENDATIONS AND/OR APPROVAL

SIGNATURE	PRINT NAME	DATE

Appendix 3: *Static Draft Form*

Static Draft Determination

Field Unit: NOAA Ship NANCY FOSTER

Date: 3/10/2006

Location: Pier Papa, Charleston, SC
32/51/05 N, 079/56/45 W

Bench Mark Method

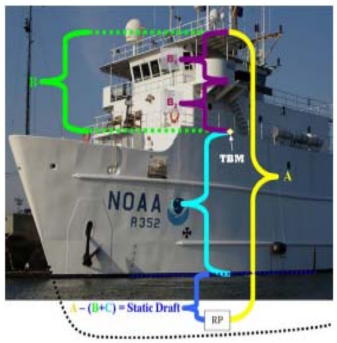
static measurements

A= 14.186
B= 5.018
B_1= 2.462
B_2= 2.585

variable measurments

C= 6.99

RP Static Draft= 2.178



Notes: The B_1 measurement incorporates the thickness of both the flying bridge and bridge deck plates (0.006m each).

Keel Draft Marks Method

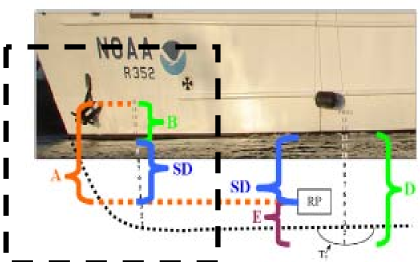
static measurements

A= 3.504

variable measurments

B= 1.397

RP Static Draft= 2.107



Projection Draft Marks Method

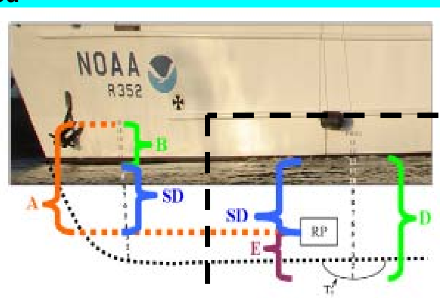
static measurements

E= 1.676

variable measurments

D= 3.734

RP Static Draft= 2.058



Appendix 4: *Dynamic Draft Form*

Dynamic Draft Determination, HSSR 2006
NOAA Ship NANCY FOSTER

A

RPM	COG	Line	# of Samples		Line Speed (kts)		Line Depth		Speed		Depth		Delta Draft
			Speed	*Depth*	*Avg.*	*σ*	*Med.*	*σ*	*Avg.*	*σ*	*Avg.*	*σ*	
0	n/a	1	474	8640	0.94	0.12	37.78	0.09	**1.83**	0.12	37.78	0.09	**0.00**
	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a					
790	91	5	95	1391	4.57	0.12	37.74	0.07	**6.60**	0.13	37.75	0.07	**0.03**
	271	6	102	1550	2.23	0.14	37.77	0.08					
1000	91	7	70	1045	3.23	0.28	37.68	0.08	**6.10**	0.21	37.69	0.08	**0.09**
	270	8	73	1160	3.06	0.13	37.71	0.08					
1300	91	9	54	813	4.20	0.10	37.74	0.08	**7.87**	0.11	37.80	0.08	**-0.01**
	271	10	57	871	3.91	0.12	37.85	0.08					
1600	91	11	43	611	5.19	0.08	37.74	0.09	**9.82**	0.10	37.75	0.08	**0.03**
	271	12	45	681	4.93	0.11	37.76	0.08					

B

RPM	COG	Line	# of Samples		Line Speed (kts)		Line Depth		Speed		Depth		Delta Draft
			Speed	*Depth*	*Avg.*	*σ*	*Med.*	*σ*	*Avg.*	*σ*	*Avg.*	*σ*	
0	n/a	2	352	5426	0.68	0.11	37.86	0.08	**1.33**	0.11	37.86	0.08	**0.00**
	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a					
790	91	5	103	1541	2.19	0.15	37.99	0.08	**4.26**	0.15	37.89	0.08	**-0.03**
	271	6	103	1558	2.20	0.14	37.79	0.08					
1000	91	7	71	1001	3.17	0.29	38.05	0.09	**6.09**	0.22	37.94	0.08	**-0.08**
	270	8	72	1076	3.11	0.14	37.83	0.08					
1300	91	9	55	796	4.13	0.12	37.95	0.08	**7.90**	0.11	37.87	0.08	**-0.01**
	271	10	56	849	4.01	0.10	37.80	0.08					
1600	91	11	45	702	5.04	0.11	37.76	0.08	**9.70**	0.13	37.80	0.08	**0.06**
	271	12	45	698	4.95	0.16	37.84	0.08					

C

RPM	COG	Line	# of Samples		Line Speed (kts)		Line Depth		Speed		Depth		Delta Draft
			Speed	*Depth*	*Avg.*	*σ*	*Med.*	*σ*	*Avg.*	*σ*	*Avg.*	*σ*	
0	n/a	3	572	19487	0.47	0.15	38.02	0.09	**0.91**	0.15	38.02	0.09	**0.00**
	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a					
790	91	5	100	1454	2.27	0.14	37.94	0.07	**4.35**	0.18	38.00	0.08	**0.02**
	271	6	103	1393	2.21	0.22	38.06	0.09					
1000	91	7	70	1006	3.21	0.25	37.85	0.08	**6.26**	0.20	37.90	0.08	**0.11**
	270	8	70	969	3.25	0.15	37.96	0.09					
1300	91	9	55	817	4.08	0.13	37.98	0.08	**8.01**	0.13	37.98	0.08	**0.03**
	271	10	54	784	4.18	0.14	37.99	0.09					
1600	91	11	43	603	5.23	0.16	37.96	0.08	**9.85**	0.14	38.01	0.08	**0.00**
	271	12	46	689	4.94	0.13	38.07	0.08					

See the Excell spreadsheet "NANCY_FOSTER_Dynamic_Draft_2006.xls," located in Appendix 9 of the digital report package, for the source data set.

Appendix 5: *Hydrographic System Wiring Diagram*


STORES
1.5-21-1-A
120 vAC
TO
220 vAC
TRANSFORMER
W6
WET LAB
120 Vac
UPS
POWER
W5
DRY LAB
MONITOR
W10
EM 1002
REMOTE
ON/OFF
EM 1002
TRANSCEIVER
W2
LAN
EM 1002
WORKSTATION
Processing
Computer
LAN
W7
W8
W9
CTD
NEW 02 DECK
POS/MV
ANTENNAS
W11-W18
POS/MV
PROCESSOR
Trimble
EM 1002
TRANSCEIVER
J-BOX
COMPUTER
LAB
W19-W26
SONAR VOID
2-25-0-E
IMU
SSVS
W1
Serial
EM 1002
TRANSDUCER
NOAA Ship NANCY FOSTER
Preliminary Wiring Diagram
REVISIONS
ZONE
REV
DESCRIPTION
DATE
APPROVED
DWG#
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES
ANGLES
2 PLACE DECIMAL XX ±.03
3 PLACE DECIMAL XXX ±.010
PART SHALL BE FREE OF BURRS
BROKEN EDGES .020 MAX
FILLETS MAX
SURFACE ROUGHNESS
DO NOT SCALE DRAWING
CONTRACT NO.
PROJECT NAME
DRAWN
CHECK
DES ENGR
SIZE
D
CAGE CODE
DWG NO.
SCALE
UNIT WT
SHEET 1 OF
AUTOCAD GENERATED DRAWING
FILE NAME:

Appendix 6: *POS/MV Calibration Report*

```
Input/Output Ports Set-up
      COM1
            Baud Rate=19200
            Parity=None
            Data Bits=8 Bits
            Stop Bits=1 Bit
            Flow Control=None
            Output Select=NMEA
                  NMEA Output=GGA,ZDA,VTG
                  Update Rate=10 Hz
                  Talker ID=IN
            Roll Positive Sense=Port Up
            Pitch Positive Sense=Bow Up
            Heave Positive Sense=Heave Up
            Input Select=None
      COM2
            Baud Rate=19200
            Parity=None
            Data Bits=8 Bits
            Stop Bits=1 Bit
            Flow Control
            Output Select=Binary
                  Binary Output
                        Update Rate=100 Hz
                        Frame=Sensor 1
                        Formula Select=SIMRAD 1000 (Tate-Bryant)
            Roll Positive Sense=Port Up
            Pitch Positive Sense=Bow Up
            Heave Positive Sense=Heave Up
            Input Select=None
      COM3
            Baud Rate=19200
            Parity=None
            Data Bits=8 Bits
            Stop Bits=1 Bit
            Flow Control=None
            Output Select=None
            Input Select=Base 1 GPS
            Base GPS Input
                  Input Type=RTCM 1 or 9
                  Line=Serial

Ethernet Logging Control
      Logging Group Select=111,113
      Logging Control
            Output Rate (groups 1, 102, 103)=20 Hz

Ethernet Realtime Output Control
      Output Group Select=1,22,3,7,10,111,113
      Output Control
            Output Rate (groups 1,102, 103)=2 Hz

Events
      Event 1=Positive Edge Trigger
```

```
      Event 2=Positive Edge Trigger

GAMS Parameter Setup
      Two Antenna Separation (m)=2.253
      Heading Calibration Threshold (deg)=0.700
      Heading Correction (deg)=0.000
      Baseline Vector
            X Component (m)=-2.253
            Y Component (m)=0.027
            Z Component (m)=0.011

Heave Filter
      Heave Filter
            Heave Bandwith (sec)=18.000
            Damping Ratio=0.707

Lever Arms & Mounting Angles
      Lever Arms & Mounting Angles
            Ref. to IMU Lever Arm
                  X (m)=0.737
                  Y (m)=0.001
                  Z (m)=-0.125
            IMU Frame w.r.t. Ref. Frame
                  X (deg)= -0.009
                  Y (deg)=-0.006
                  Z (deg)=0.057
            Ref. to Primary GPS Lever Arm
                  X (m)=6.571
                  Y (m)=-4.740
                  Z (m)=-16.308
            Ref. to Vessel Lever Arm
                  X (m)=0.000
                  Y (m)=0.000
                  Z (m)=0.000
            Ref. to Centre of Rotation Lever Arm
                  X (m)=-12.295
                  Y (m)=0.000
                  Z (m)=-1.965
      Sensor Mounting
            Ref. to Aux. 1 GPS Lever Arm
                  X (m)=0.000
                  Y (m)=0.000
                  Z (m)=0.000
            Ref. to Aux. 2 GPS Lever Arm
                  X (m)=0.000
                  Y (m)=0.000
                  Z (m)=0.000
            Ref. to Sensor 1 Lever Arm
                  X (m)=0.000
                  Y (m)=0.000
                  Z (m)=0.000
            Sensor 1 Frame w.r.t. Ref. Frame
                  X (deg)=0.000
                  Y (deg)=0.000
```

```
                        Z (deg)=0.000
                  Ref. to Sensor 2 Lever Arm
                        X (m)=0.000
                        Y (m)=0.000
                        Z (m)=0.000
                  Sensor 2 Frame w.r.t. Ref. Frame
                        X (deg)=0.000
                        Y (deg)=0.000
                        Z (deg)=0.000
            Tags, Multipath & AutoStart
                  Time Tag 1=UTC Time
                  Time Tag 2=GPS Time
                  AutoStart=Enabled
                  Multipath=Low

      Statistics
            POS Version= MV-320,VER4,S/N2249,HW2.7-7,SW03.22-
Feb08/06,ICD03.17,OS425B14,IMU2,PGPS13,SGPS13,RTK-0,THV-0,DPW-0
            GPS Receivers
                  Primary Receiver=BD950;SN:4520A58693,v.00211,channels:24
                  Secondary Receiver=BD950:SN:4520A58705,v.00211,channels:24
            Statistics
                  Total Hours=1238.4
                  Total Runs=31
                  Average Run (hours)=39.9
                  Longest Run (hours)=623.0
                  Current Run (hours)=111.8

      Navigator Configuration
            Frame Contol=User Frame
            Auxiliary GPS Position=Normal
            Primary GPS Measurement=Normal
            GAMS=unchecked Disable GAMS Solution

      POS Internet Address
            POS Internate Address=010.048.002.012
            Subnet Mask=255.000.00.000

      Gps Receiver Configuratioin
            Primary GPS Receiver
                  Primary GPS
                        GPS Output Rate=1 Hz
                  GPS 1 Port
                        Baud Rate=9600
                        Parity=None
                        Data Bits=8 Bits
                        Stop Bits=1 Bit
                  Auto Configuratioin
                        Enabled
            Secondary GPS Receiver
                  Secondary GPS
                        GPS Output Rate=1 Hz
                  GPS 2 Port
                        Baud Rate=9600
```

```
            Parity=None
            Data Bits=8 Bits
            Stop Bits=1 Bit
      Auto Configuratiion
            Enabled

User Parameter Accuracy
      RMS Accuracy
            Attitude (deg)=0.050
            Headinig (deg)=0.050
            Position (m)=2.000
            Velocity (m/s)=0.500
```

Appendix 7: *Sounding System Comparison Form*

Sounding Systems Comparison

Field Unit: NOAA Ship NANCY FOSTER

Date & Time	Location (Lat, Lon)	Sounding System Models & Serial Numbers	Raw Measurement (m)*	Computed Depth (m)*	System Operator	Comments
3/10/2006	Pier Papa, Charleston, SC 32/51/05 N, 079/56/45 W	lead line: NANCY FOSTER s/n 1	16.15	9.16	PS Nick Forfinski	inconclusive; lead line taken at edge of dredged area under ship along pier; see 2006 HSSR for details
		EM 1002, s/n 288 (Tx)	n/a	inconclusive	PS Nick Forfinski	

****NOTE:*** *A raw lead line measurement is considered the distance from the port 02-deck benchmark to the bottom. A computed lead line depth equals the raw measurement minus the benchmark-to-water surface vertical distance. A raw EM 1002 measurement is considered to be MERLIN's output depth, which is already corrected for the waterline. A computed EM 1002 depth is considered to be the depth after CARIS processing.*

Appendix 8: *Verification Patch Test Form*

Multibeam Echosounder Calibration

Field Unit: NOAA Ship NANCY FOSTER

Date of Test: March 7-8, 2006

Calibrating Hydrographer(s): PS Nick Forfinski, Contractor Mike Stecher

MULTIBEAM SYSTEM INFORMATION

Multibeam Echosounder System: Kongsberg EM 1002

System Location: PU - dry stores, Acquisition Computer - Dry lab

Sonar Serial Number: 288

Processing Unit Serial Number: 303

Date of Most Recent EED / Factory Checkout: Early March, 2006

VESSEL INFORMATION

Sonar Mounting Configuration: hull-mounted on starboard side, near frame 25

Date of Current Vessel Offset Measurement / Verification: 02/08/06

Description of Positioning System: POS/MV 320 version 4

Date of Most Recent Positioning System Calibration: March 1, 2006

TEST INFORMATION

Test Date(s) / DN(s): March 7-8, 2006 (dn 066 and dn067)

System Operator(s): Kongsberg Representative Chuch Hohing

Wind / Seas / Sky:

Locality: ~40-45 nm offshore Charleston, SC

Sub-Locality: Edge of 1st tier of continental shelf

Bottom Type: unknown

Approximate Average Water Depth: 36m for roll/heading/outer beam; 80-90m for nav/pitch

DATA ACQUISITION INFORMATION

Line Number	Heading	Speed
0003_20060307_031718 - *timing*	344°	3.74
0001_20060307_024405 - *timing/pitch*	344°	7.37
0002_20060307_030017 - *pitch*	165°	6.4
0004_20060308_030121 - *roll*	34°	5.05
0003_20060308_024619 - *roll*	214°	5.01
0001_20060308_064948 - *heading*	234°	5.65
0003_20060308_071725 - *heading*	234°	5.38
0003_20060308_052547 - *outer beam*	126°	5.19
0004_20060308_054033 - *outer beam*	310°	5.61
0001_20060308_041437 - *outer beam*	132°	5.64

TEST RESULTS

Navigation Timing Error: 1 sec

Pitch Timing Error: n/a

Roll Timing Error: n/a

Pitch Bias: -1.2

Roll Bias: -0.165

Heading Bias: See narrative below

Outer Beam Angle Offset: See narrative below

Resulting CARIS HIPS HVF File Name: R352_mb.hvf

NARRATIVE

A truly independent estimate of the gyro and outer beam angle offset biases could not be performed, because the gyro and outer beam angle offset calibration lines were acquired with the Kongsberg-derived estimate of the roll bias entered into the EM1002 installation parameters, as per Kongsberg's standard procedure of entering a particular bias estimate into the installation parameters before acquiring the data to estimate the next bias. Since the Kongsberg bathymetry datagram is what gets read into CARIS's observed depth files, the CARIS processed depth data, which are what a CARIS user sees when in calibration mode, are already corrected for whatever bias estimates are entered into the EM1002 installation parameters. The OCS liaison was able to estimate independently the timing, pitch, and roll biases because the Kongsberg estimates happened to be 0. In the future, to adhere to the HSSD criterion that corrections shall be applied in such a way that correctors may be removed and replaced with a revised set of correctors in post-processing, NANCY FOSTER will correct for timing, pitch, roll, will correct for timing, pitch, roll, and gyro calibration biases in CARIS, by entering the bias estimates in the appropriate fields within the swath1 sensor of the hvf. The OCS ship liaison recommends that NANCY FOSTER performs another timing and pitch bias estimation before commencing regular survey operations.

Appendix 9: *Reference Surface QC Report*

NOAA Ship NANCY FOSTER
HSSR 2006 - Reference Surface CARIS QC Report

Beam Number	Count	Max (+)	Min (-)	Mean	Std Dev	Special Order (%)	Order 1 (%)	Order 2 (%)	Order 3 (%)
1-2	43562	5.504	3.808	0.236	0.307	28.3	59.5	97	97
2-3	43754	3.79	2.347	0.212	0.262	28.8	61.9	98.2	98.2
3-4	43928	4.326	3.656	0.188	0.242	31	65.3	98.9	98.9
4-5	43945	4.367	2.122	0.171	0.215	33	67.6	99.5	99.5
5-6	43955	4.016	1.839	0.158	0.203	34.7	70	99.7	99.7
6-7	43958	4.841	2.776	0.142	0.19	37.6	73.1	99.9	99.9
7-8	43959	3.173	2.366	0.123	0.184	41.3	76.6	99.9	99.9
8-9	43963	3.299	2.855	0.114	0.176	42.6	78.8	99.9	99.9
9-10	43964	4.792	2.991	0.102	0.178	46	79.7	100	100
10-11	43965	4.253	1.213	0.089	0.166	48	83.8	100	100
11-12	43968	2.455	1.283	0.074	0.16	51.7	86.2	100	100
12-13	43968	3.315	2.638	0.059	0.156	55.6	88.6	100	100
13 - 14	43959	4.215	1.223	0.051	0.151	57.1	90.1	100	100
14 - 15	43970	6.064	4.261	0.04	0.151	60.1	91.9	100	100
15 - 16	43970	7.054	1.396	0.039	0.146	60.1	92.6	100	100
16 - 17	43969	8.054	1.449	0.032	0.144	62.2	93.7	100	100
17 - 18	43968	9.141	1.551	0.018	0.144	66.2	94.9	100	100
18 - 19	43971	2.583	1.486	0.013	0.135	67.6	95.6	100	100
19 - 20	43969	2.001	1.502	-0.002	0.132	72.1	96.9	100	100
20 - 21	43970	1.687	1.53	-0.017	0.129	76.3	97.9	100	100
21 - 22	43968	1.154	1.485	-0.024	0.127	77.9	98.5	100	100
22 - 23	43969	1.729	1.457	-0.026	0.127	78.5	98.8	100	100
23 - 24	43969	1.706	1.216	-0.032	0.126	80.1	99.1	100	100
24 - 25	43969	1.385	1.081	-0.03	0.125	79.6	99.1	100	100
25 - 26	43970	1.094	1.722	-0.035	0.124	81.3	99	100	100
26 - 27	43970	1.163	2.67	-0.036	0.124	81.6	99.2	100	100
27 - 28	43971	0.773	1.52	-0.035	0.125	81.3	99.2	100	100
28 - 29	43971	0.625	1.101	-0.049	0.126	84.1	99.4	100	100
29 - 30	43971	1.092	1.159	-0.062	0.127	87.1	99.6	100	100
30 - 31	43971	1.011	3.568	-0.062	0.131	86.3	99.6	100	100
31 - 32	43971	0.92	2.343	-0.059	0.126	86.4	99.6	100	100
32 - 33	43971	1.166	2.073	-0.054	0.125	86	99.6	100	100
33 - 34	43968	0.916	1.451	-0.027	0.145	76.2	97.2	100	100
34 - 35	43971	1.07	1.182	-0.046	0.135	81.8	99.1	100	100
35 - 36	43971	0.555	1.18	-0.047	0.134	82.3	99.3	100	100
36 - 37	43971	1.01	1.159	-0.049	0.136	82.1	99.2	100	100
37 - 38	43968	1.018	1.096	-0.055	0.139	83.2	99	100	100
38 - 39	43970	1.072	0.964	-0.058	0.138	83.7	99.3	100	100
39 - 40	43971	0.754	0.898	-0.05	0.126	84.3	99.5	100	100
40 - 41	43971	1.003	1.301	-0.051	0.125	84.5	99.4	100	100
41 - 42	43971	0.873	3.905	-0.055	0.128	85.6	99.3	100	100
42 - 43	43971	1.848	0.859	-0.059	0.124	86.5	99.4	100	100
43 - 44	43970	0.888	1.024	-0.055	0.126	85.2	99.3	100	100
44 - 45	43969	2.424	1.1	-0.058	0.131	85.3	99.2	100	100
45 - 46	43969	2.134	1.099	-0.06	0.135	84.7	98.8	100	100
46 - 47	43968	2.345	1.71	-0.061	0.138	84.4	98.7	100	100
47 - 48	43970	2.167	1.463	-0.064	0.14	85.2	98.7	100	100
48 - 49	43970	2.015	1.912	-0.062	0.139	85.2	98.6	100	100
49 - 50	43963	2.326	1.188	-0.067	0.142	85.2	98.2	100	100
50 - 51	43970	1.931	1.392	-0.076	0.143	86	98.6	100	100
51 - 52	43971	1.559	1.628	-0.079	0.144	86.3	98.8	100	100
52 - 53	43972	0.533	1.228	-0.085	0.139	87.6	99.2	100	100
53 - 54	43953	0.817	1.702	-0.101	0.134	91.2	99.7	100	100
54 - 55	43971	1.114	1.064	-0.108	0.128	93.2	99.8	100	100

55 - 56	43972	1.361	0.936	-0.108	0.122	94	99.8	100	100
56 - 57	43972	0.929	0.837	-0.115	0.12	95.1	99.9	100	100
57 - 58	43959	0.81	1.103	-0.103	0.124	92.9	99.8	100	100
58 - 59	43971	1.232	0.78	-0.1	0.128	91.9	99.7	100	100
59 - 60	43972	0.74	1.111	-0.092	0.131	90.3	99.7	100	100
60 - 61	43970	0.92	1.601	-0.076	0.139	86.6	99.2	100	100
61 - 62	43964	1.608	1.724	-0.071	0.143	85.4	98.8	100	100
62 - 63	43970	1.573	1.568	-0.069	0.139	85.8	98.6	100	100
63 - 64	43972	1.057	1.597	-0.064	0.134	85.7	98.6	100	100
64 - 65	43969	1.381	3.561	-0.063	0.136	86.3	98.8	100	100
65 - 66	43971	1.97	1.539	-0.064	0.134	86.5	98.8	100	100
66 - 67	43970	1.968	1.495	-0.067	0.134	86.7	99.1	100	100
67 - 68	43970	1.662	1.15	-0.069	0.13	87.7	99.3	100	100
68 - 69	43971	0.806	1.043	-0.069	0.127	88	99.4	100	100
69 - 70	43968	1.88	2.317	-0.066	0.125	88.6	99.5	100	100
70 - 71	43970	1.803	1.529	-0.07	0.119	90.4	99.7	100	100
71 - 72	43969	0.803	0.887	-0.07	0.117	90.6	99.8	100	100
72 - 73	43969	2.782	0.904	-0.069	0.119	90.3	99.8	100	100
73 - 74	43971	0.997	0.986	-0.064	0.118	89.1	99.7	100	100
74 - 75	43971	1.098	0.961	-0.074	0.128	89.4	99.7	100	100
75 - 76	43971	0.914	1.493	-0.069	0.122	89.6	99.8	100	100
76 - 77	43971	1.179	1.001	-0.056	0.12	87.3	99.7	100	100
77 - 78	43970	1.05	0.815	-0.047	0.123	85	99.3	100	100
78 - 79	43970	0.777	1.03	-0.048	0.12	86	99.6	100	100
79 - 80	43971	0.843	1.02	-0.04	0.116	84.6	99.6	100	100
80 - 81	43971	0.904	1.067	-0.056	0.113	88.8	99.8	100	100
81 - 82	43971	0.82	1.096	-0.061	0.115	89.7	99.8	100	100
82 - 83	43970	1.066	1.247	-0.057	0.117	88.3	99.8	100	100
83 - 84	43970	0.911	1.418	-0.053	0.118	86.9	99.7	100	100
84 - 85	43970	0.84	1.748	-0.039	0.118	83.9	99.5	100	100
85 - 86	43970	1.145	1.481	-0.027	0.118	81	99.2	100	100
86 - 87	43970	0.899	1.379	-0.021	0.118	79.1	99.1	100	100
87 - 88	43970	0.688	1.442	-0.014	0.118	77.5	98.8	100	100
88 - 89	43969	0.621	1.284	-0.01	0.121	75.4	98.5	100	100
89 - 90	43969	0.495	1.101	-0.012	0.121	76	98.6	100	100
90 - 91	43970	0.575	1.352	-0.001	0.123	72.7	97.8	100	100
91 - 92	43970	1.532	1.014	0.006	0.122	71.2	97.5	100	100
92 - 93	43970	1.268	1.22	0.014	0.125	68.8	96.3	100	100
93 - 94	43969	0.645	0.823	0.025	0.13	66.1	94.6	100	100
94 - 95	43969	0.669	0.958	0.05	0.134	58.4	92.2	100	100
95 - 96	43970	1.463	1.019	0.058	0.136	56.1	90.9	100	100
96 - 97	43969	0.737	1.065	0.07	0.139	52.7	89.1	100	100
97 - 98	43969	0.884	1.037	0.074	0.145	51.9	87.7	100	100
98 - 99	43970	0.891	1.209	0.079	0.15	51	86.2	100	100
99 - 100	43969	0.824	1.203	0.088	0.153	49	84.7	100	100
100 - 101	43969	0.89	1.092	0.092	0.162	48.4	82.9	100	100
101 - 102	43969	3.17	1.641	0.105	0.171	46.3	80.3	100	100
102 - 103	43969	3.623	1.747	0.124	0.174	41.4	77	100	100
103 - 104	43969	5.662	0.792	0.137	0.185	39.7	73.9	100	100
104 - 105	43968	4.041	1.704	0.149	0.189	37.6	71.6	99.9	99.9
105 - 106	43969	5.669	1.203	0.156	0.204	37.6	69.6	99.8	99.8
106 - 107	43969	5.075	1.926	0.184	0.204	31.6	64.6	99.7	99.7
107 - 108	43962	6.302	5.198	0.202	0.221	29.5	61.7	99.5	99.5
108 - 109	43964	4.848	1.064	0.217	0.231	27.5	59.3	99.3	99.3
109 - 110	43940	6.315	1.461	0.232	0.265	27.7	57.9	98.5	98.5
110 - 111	43827	4.792	2.887	0.263	0.28	23.9	53.2	97.4	97.4
111 - 112	43620	5.325	1.499	0.29	0.328	23.9	51.8	95.6	95.6

Appendix 10: *SSS Tow-point Offset Report*

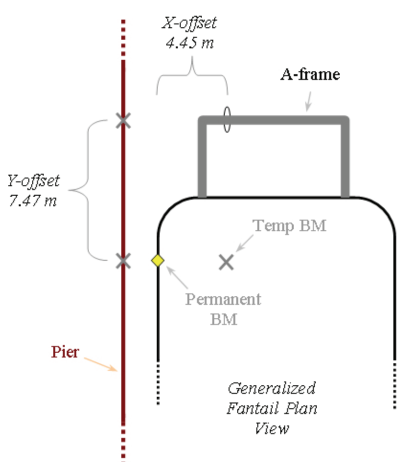
NOAA Ship NANCY FOSTER
Side Scan Sonar tow point Offset Report

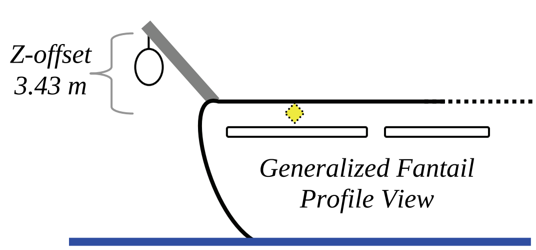
The tow-point of the SSS A-frame was not surveyed as part of the L3 Communications vessel survey; however, the OCS representatives tied the RP-to-tow-point (TP) lever arm in to the ship vessel coordinate system by estimating the x and y offsets of the tow-point from a permanent benchmark (the aft deck alignment cube) near the A-frame. The x-offset was estimated by measuring, with a steel tape, the horizontal distance from the inboard face of the alignment cube to a temporary bench mark that was visually estimated to be in-line with the SSS towpoint's athwart-ship position and the permanent benchmark's along-ship position. The y-offset was estimated, while the ship was alongside Pier Papa, Charleston, SC, by measuring the horizontal distance between a temporary pier-side benchmark that was visually estimated to be in-line with the towpoint's along-ship position and a temporary pier-side benchmark that was visually estimated to be in-line with the permanent benchmark. A z-offset was taken from a schematic of the A-frame installation and is the vertical distance from the SSS pad-eye to the fantail deck. The calculated RP-to-TP lever arm components are summarized in the table below.

Table 1: RP-to-TP Lever Arm

	RP-to-alignment cube	*Alignment cube-to-TP*	**RP-to-TP**
x-component:	5.817	-4.45	1.367
y-component	-35.945	-7.47	-43.415
z-component	-4.712	-3.43	See note below

NOTE: In CARIS, the z-component of the RP-to-TP lever arm is the vertical distance from the towpoint to the water surface, not the vertical distance from the towpoint to the reference point; the z-component of the RP-to-TP lever is dependent on the waterline.





Appendix 11: *Hydrographic Systems Inventory*

Hydrographic Vessel Inventory

Field Unit: NOAA Ship NANCY FOSTER

Effective Date:

Updated Through:

SURVEY VESSELS							
Vessel Name	NOAA Ship NANCY FOSTER 						
Hull Number	R352						
Call Letters	WTER						
Manufacturer	McDermott, Inc.						
Year of Construction	1991						
Type of Construction	Welded Steel Hull						
Length Overall	57 m (187 ft)						
Beam	12.1 m (40 ft)						
Draft	10.5 ft						
Date of Effective Full Vessel Static Offset Survey	8-Feb-06						
Organization which Conducted the Effective Full Offset Survey	L3 Communications						
Date of Last Partial Survey or Offset Verification & Methods Used	none						
Date of Last Static Draft Determination & Method Used	3/10/2006 - Benchmark/Lead line method						
Date of Last Settlement and Squat Measurements & Method Used	3/9/2006 - Echosounder method						
Additional Information							

Hydrographic Hardware Inventory

Field Unit:
Effective Date:
Updated Through:

SONAR & SOUNDING EQUIPMENT

Equipment Type	Manufacturer	Model	Serial #	Firmware and/or Software Version	Version Install Date	Date of last Calibration	Date of last Service	Additional Information
Transucer	Kongsberg	EM 1002	288			3/7/2006		111 2° beams
Transeiver Unit	Kongsberg	EM1002	303					

POSITIONING & ATTITUDE EQUIPMENT

Equipment Type	Manufacturer	Model	Serial #	Firmware and/or Software Version	Version Install Date	Date of last Calibration	Date of last Service	Additional Information
GPS Aided Inertial Naviation system - PCS	Applanix	POS/MV 320 V4	2249					Roll/Pitch Accuracy: 0.02° Heave Accuracy: the greater of 5cm or 5% for periods of 20s or less
GPS Aided Inertial Naviation system - IMU	Applanix	LN 200	447					
DGPS Reciever	Trimble	DSM 132	224096283					

SOUND SPEED MEASUREMENT EQUIPMENT

Equipment Type	Manufacturer	Model	Serial #	Firmware and/or Software Version	Version Install Date	Date of last Calibration	Date of last Service	Additional Information
Sound Speed Profiler	Sea-Bird	SBE 19	192523-355	3.0		12/12/2005		max depth = 200 m (656 ft)
Sound Speed Profiler	Sea-Bird	SBE 19+	198671-1448			12/12/2005		max depth = 200 m (656 ft)
Sound Speed Profiler	Sea-Bird	SBE 9	?			?		
Thermosalinograph	Sea-Bird	SBE 45	4540569-0155			?		

TIDES & LEVELING EQUIPMENT

Equipment Type	Manufacturer	Model	Serial #	Firmware and/or Software Version	Version Install Date	Date of last Calibration	Date of last Service	Additional Information

HORIZONTAL AND VERTICAL CONTROL EQUIPMENT

Equipment Type	Manufacturer	Model	Serial #	Firmware and/or Software Version	Version Install Date	Date of last Calibration	Date of last Service	Additional Information

OTHER EQUIPMENT

Equipment Type	Manufacturer	Model	Serial #	Firmware and/or Software Version	Version Install Date	Date of last Calibration	Date of last Service	Additional Information

Hydrographic Software Inventory

Field Unit: *NOAA Ship NANCY FOSTER* **Effective Date:** **Updated Through:**

COMPUTERS								
Machine Name	**TSG**	**Hypack**	**CTD**	**Processor**	**EM 1002**	**Science1**	**Science2**	**Echo**
Location	Dry Lab - outboard rack	Dry Lab - inboard rack	Dry Lab - inboard rack	Dry Lab - inboard rack	Dry Lab - inboard rack	Dry Lab - outboard rack	Dry Lab - outboard rack	
Make/Model	Dell Optiplex GX 620		Dell Optiplex GX 280	Dell Optiplex GX 620	Solaris Sun Blade 150	Dell Optiplex GX 620	Dell Optiplex GX 620	
Date Purchased								
Date of Last Rebuild								
Processor	Pentium D	Pentium 3/1133 MHz	Pentium 4/3.00 GHz	Pentium D	550 MHz	Pentium 4	Pentium 4	Pentium D
RAM		523,740 kb	0.99 GHz	3.5 GB	384 MB			
Video Card		MATROX millenium G450 dualhead	Intel 82915 G Express	256 MB ATI Radeon X600				
Video RAM								
Hard Drive Space		4 GB	74 GB	C: 232 GB D: 232 GB	40 GB			
Comments	not for hydro; used for SBE21 uncontaminated water system				CD ROM/Floppy drive, 2 serial line, 1 parallel port, 1 ethernet	email/general use computer for science parties	email/general use computer for science parties	current not being used; reserved for use with IES 10 deep water echsounder
SOFTWARE LICENSES								
Acquisition								
HYPACK MAX	n/a	?	n/a	n/a	n/a	n/a	n/a	n/a
Processing								
CARIS	n/a	n/a	n/a	CW9604463 (single user USB key - expires 01/31/07)	n/a	n/a	n/a	n/a
Support								
OPERATING SYSTEM PACKAGE								
Windows XP								
	?	n/a	?	?	n/a	?	?	?
Windows 2000								
	n/a	?	n/a	n/a	n/a	n/a	n/a	n/a
Solaris (UNIX)								
8	n/a	n/a	n/a	n/a	?	n/a	n/a	n/a
ACQUISITION SOFTWARE PACKAGE								
HypackMAX								
		4.3.52.0						
PROCESSING SOFTWARE PACKAGE								
CARIS GIS								
4.4a	n/a	n/a	n/a	3/7/2006	n/a	n/a	n/a	n/a
SP 5	n/a	n/a	n/a	3/7/2006	n/a	n/a	n/a	n/a
HF 1-18	n/a	n/a	n/a	3/7/2006	n/a	n/a	n/a	n/a
CARIS HIPS/SIPS								
6.0	n/a	n/a	n/a	3/7/2006	n/a	n/a	n/a	n/a
SP 1	n/a	n/a	n/a	3/7/2006	n/a	n/a	n/a	n/a
HF 1-9	n/a	n/a	n/a	3/7/2006	n/a	n/a	n/a	n/a
MS Office								
SUPPORT SOFTWARE PACKAGE								
Adobe Acrobat Professional								

Hydrographic Personnel Roster

Field Unit:

Effective Date:

Updated Through:

OFFICERS

Name and Grade	Current Position	Years of Hydrographic Experience	Notes
CDR James Verlaque	Commanding Officer		
LCDR Dave Score	Executive Officer		
ENS Tracey Hamburger	Field Operations Officer	<1	
ENS William Wells	Junior Officer		
ENS Lecia Salerno	Junior Officer		

SURVEY DEPARTMENT

Name and Rate	Current Position	Years of Hydrographic Experience	Notes
ST Dan Boles	Survey Technician		

DECK DEPARTMENT (involved in survey work)

Name and Rate	Current Position	Years of Hydrographic Experience	Notes
Cornell Hill	Chief Boatswain		
Brad Delinski	Boatswain Group Leader		
David Leapheart	AB		
Greg Walker	AB		

ROTATING HYDROGRAPHERS & VISITORS (involved in survey work)

Name and Rate	Current Position	Years of Hydrographic Experience	Notes & Dates Embarked
	Physical Scientist		

NOTES:

Appendix 12: *EM 1002 Installation Parameters*

```
# Sounder: EM1002
# This file may be modified by any ASCII
editor. Illegal values
# may have unpredible results. For safe
updates, use the 'File->Save
# or the 'File->Save As...' button in
the Echo Sounder Parameters Window.
esoSwVersion=5.2.0 020930
# Serial port no. 0
interfaceIndex=0
sensorType=18
baudRate=4
noDataBits=1
noStopBits=0
parity=0
enabledStatus=0,0,0,0,1,0,0,0,0,0,0,0,0
# Serial port no. 1
interfaceIndex=1
sensorType=256
baudRate=4
noDataBits=1
noStopBits=0
parity=0
enabledStatus=0,0,0,0,0,0,1,0,0,0,0,0,0
# Serial port no. 2
interfaceIndex=2
sensorType=0
baudRate=3
noDataBits=1
noStopBits=0
parity=0
enabledStatus=0,0,0,0,0,0,0,0,0,0,0,0,0
# Serial port no. 3
interfaceIndex=3
sensorType=0
baudRate=3
noDataBits=1
noStopBits=0
parity=0
enabledStatus=0,0,0,0,0,0,0,0,0,0,0,0,0
# Ethernet Setup
interfaceIndex=4
sensorType=0
baudRate=0
noDataBits=1
noStopBits=0
parity=0
enabledStatus=0,0,0,0,0,0,0,0,0,0,0,0,1
# Positioning System no. 0
posIndex=0
geoid=WGS_84
forwardPos=0.00
starboardPos=0.00
downwardPos=0.00
posDelay=0.00
timeToUse=1
motionCorrection=1
projection=0
# Positioning System no. 1
posIndex=1
geoid=WGS_84
forwardPos=0.00
starboardPos=0.00
downwardPos=0.00
posDelay=0.00
timeToUse=0
motionCorrection=0
projection=0
# Positioning System no. 2
posIndex=2
geoid=WGS_84
forwardPos=0.00
starboardPos=0.00
downwardPos=0.00
posDelay=0.00
timeToUse=0
motionCorrection=0
projection=0
# Positioning System no. 3
posIndex=3
geoid=WGS_84
forwardPos=0.00
starboardPos=0.00
downwardPos=0.00
posDelay=0.00
timeToUse=0
motionCorrection=0
projection=0
waterlevelDownwardPos=-2.11
attForwardPos=0.00
attStarboardPos=0.00
attDownwardPos=0.00
attSensorDelay=0.000000
attRollOffset=-0.14
attPitchOffset=0.00
attHeadingOffset=0.00
attRollRefPlane=1
attHeadingStatus=0
headingSource=1
motionSensorSource=1
headingFormat=0
headingOffset=0.00
activePosSys=0
clockSync=1
clockOffset=0
use1PPS=1
externalTrigging=0
posFiltering=0
maxSpeed=25
attScaling=1.000
heaveApplied=1
hullUnit=0
hullUnitTiltOffset=0.00
hiloFrqGainDiff=6.0
outerBeamOffset=-0.1800
tdForwardPos=0.81
tdStarboardPos=1.86
tdDownwardPos=1.68
tdHeadingReBow=0.03
tdRoll=-0.01
tdPitch=0.05
tdGainOffset=0.0
```

Appendix 13: *HYPACK Configuration Report*

```
Device=POSMV Serial
      Device Setup
            Update frequency (ms)=50
            Type=Position,Heading,Speed,Sync. Clock
            Option=Record raw data,Record quality data,Record message
            Driver=c:\hypack\devices\kinematic.dll
            Connect
                  Connect to=Serial Port
                  Setting=COM2,9600,n,8,1
            Offsets
                  Latency time (sec)=0.000
                  Starboard (m/ft)=0.00
                  Forward (m/ft)=0.00
                  Height (m/ft)=0.00
                  Yaw (deg)=0.00
                  Roll (deg)=0.00
                  Pitch (deg)=0.00
            Setup
                  General
                        (nothing checked)
                  Alarms
                        Max. HDOP value=4.0, show alarm
                        Min. number of satts=4, show alarm
                        GPS status codes conforming to NMEA 2.1 standard
                  GPS Status Codes
                        Invalid=0, show alarm
                        Stand alone=1, show alarm
                        Differential=2
                        RTK Float=3
                        RTK Fixed=3
                  Advanced
                        Used
                        Sentences=PTNL,GGK;PTNL,QA;VTG;RMC;GGA;HDT;GGK;GST;GLL;
                                  GNS
```

Appendix 14: *HVF Vessel Report & TPE Report*

```
Vessel Name: R352_MB.hvf
Vessel created: March 13, 2006


Depth Sensor:

      Sensor Class:      Swath
      Time Stamp:  2006-064 00:00

      Transduer #1:
      -------------
      Pitch Offset:     0.000
      Roll Offset:      0.000
      Azimuth Offset:   0.000

      DeltaX:     0.000
      DeltaY:     0.000
      DeltaZ:     0.000

      Manufacturer:
      Model:             em1002
      Serial Number:
```

```
Navigation Sensor:

      Time Stamp:  2006-064 00:00

      Comments
      Latency 0.000
      DeltaX:     0.000
      DeltaY:     0.000
      DeltaZ:     0.000

      Manufacturer:
      Model:
      Serial Number:
```

```
Gyro Sensor:

      Time Stamp:  2006-064 00:00

      Comments (null)
      Latency 0.000

      Entry 0) Draft: 0.000   Speed: 0.000
```

```
Heave Sensor:

      Time Stamp:  2006-064 00:00

      Comments Caris TechNote - SV Corrections for Simrad.pdf  072303
      Apply No
```

```
    Latency 0.000
    DeltaX:     0.000
    DeltaY:     0.000
    DeltaZ:     0.000

    Manufacturer:      (null)
    Model:             (null)
    Serial Number:     (null)
```

```
Pitch Sensor:

    Time Stamp:  2003-111 00:00

    Comments Caris TechNote - SV Corrections for Simrad.pdf  072303
    Apply No
    Latency 0.000
    Pitch offset: 0.000

    Manufacturer:      (null)
    Model:             (null)
    Serial Number:     (null)
```

```
Roll Sensor:

    Time Stamp:  2006-064 00:00

    Comments Caris TechNote - SV Corrections for Simrad.pdf  072303
    Apply No
    Latency 0.000
    Roll offset: 0.000

    Manufacturer:      (null)
    Model:             (null)
    Serial Number:     (null)
```

```
Draft Sensor:

    Time Stamp:  2006-064 00:00

    Apply Yes
    Comments (null)
    Entry 1) Draft: 0.000   Speed: 0.000
    Entry 2) Draft: 0.007   Speed: 5.068
    Entry 3) Draft: 0.041   Speed: 6.151
    Entry 4) Draft: 0.002   Speed: 7.924
    Entry 5) Draft: 0.032   Speed: 9.789
```

```
TPE

    Time Stamp:  2006-064 00:01
```

```
Comments
Offsets

Motion sensing unit to the transducer 1
      X Head 1 0.074
      Y Head 1 1.855
      Z Head 1 1.801
Motion sensing unit to the transducer 2
      X Head 2 0.000
      Y Head 2 0.000
      Z Head 2 0.000
Navigation antenna to the transducer 1
      X Head 1 5.760
      Y Head 1 6.596
      Z Head 1 17.984
Navigation antenna to the transducer 2
      X Head 2 0.000
      Y Head 2 0.000
      Z Head 2 0.000

Roll offset of transducer number 1 -0.014
Roll offset of transducer number 2 0.000

Heave Error: 0.050 or 5.000'' of heave amplitude.
Measurement errors: 0.020
Motion sensing unit alignment errors
Gyro:0.000  Pitch:0.000 Roll:0.000
Gyro measurement error: 0.020
Roll measurement error: 0.020
Pitch measurement error: 0.020
Navigation measurement error: 0.500
Transducer timing error: 0.000
Navigation timing error: 0.100
Gyro timing error: 0.010
Heave timing error: 0.010
PitchTimingStdDev: 0.010
Roll timing error: 0.010
Sound Velocity speed measurement error: 0.600
Surface sound speed measurement error: 0.500
Tide measurement error: 0.010
Tide zoning error: 0.100
Speed over ground measurement error: 0.250
Dynamic loading measurement error: 0.000
Static draft measurement error: 0.030
Delta draft measurement error: 0.000
```

```
Svp Sensor:

      Time Stamp:  2006-064 00:00

      Comments (null)
      Svp #1:
      -------------
      Pitch Offset:     0.000
```

```
Roll Offset:      0.000
Azimuth Offset:   0.000

DeltaX:     0.811
DeltaY:     1.856
DeltaZ:     1.676

SVP #2:
-------------
Pitch Offset:     0.000
Roll Offset:      0.000
Azimuth Offset:   0.000

DeltaX:     0.000
DeltaY:     0.000
DeltaZ:     0.000


Time Stamp:  2006-065 00:00

Comments
Svp #1:
-------------
Pitch Offset:     0.000
Roll Offset:      0.000
Azimuth Offset:   0.000

DeltaX:     0.000
DeltaY:     0.000
DeltaZ:     0.000

SVP #2:
-------------
Pitch Offset:     0.000
Roll Offset:      0.000
Azimuth Offset:   0.000

DeltaX:     0.000
DeltaY:     0.000
DeltaZ:     0.000
```

```
WaterLine:

      Time Stamp:  2006-064 00:00

      Comments
      Apply No
      WaterLine 0.000
```

Total Propagated Error (TPE) Report

NOAA Ship NANCY FOSTER

2006

Caris HIPS 6.0 has an error model that derives from a sounding's source errors the total propagated error (TPE) for that sounding. The sources of the estimates of the various errors vary from manufacturers' specifications, to theoretical values, to field tested empirical observations. The error estimates (one sigma) are entered into the TPE sensor section of an HVF.

Below is a table listing various source errors and their estimate, followed by a detailed discussion describing each error estimate.

Error Source	Error Estimate
Heave % Amplitude	5.0
Heave	0.05
Gyro	0.02
Roll	0.02
Pitch	0.02
Navigation	0.5
Timing Transducer	unknown
Navigation Timing	unknown
Gyro Timing	0.01
Heave Timing	0.01
Pitch Timing	0.01
Roll Timing	0.01
Sound Velocity Measured	0.5
Surface	0.5
Tide Measured	0.01
Tide Zoning	0.1
Offset X	0.02
Offset Y	0.02
Offset Z	0.02
Vessel Speed	0.25
Loading	unknown
Draft	0.03
Delta Draft	unknown

Detailed Discussion of Error Estimates

Heave % Amplitude

Error: 5

Definition: *Heave % Amplitude* is an additional heave standard deviation component that is the percentage of the instantaneous heave.

Discussion: See *Heave* discussion below.

Heave

Error: 0.05

Definition: *Heave* is the measurement for standard deviation of the heave data in meters.

Discussion: The POS/MV heave error is given as 0.05 meters + 5% of heave; however, the Caris error model implementation uses *Heave* or *Heave % Amplitude*, whichever is greater (see *Heave* discussion below). Thus, a value of 0.06 for *Heave* is used as a compromise.

Gyro

Error: 0.02

Definition: *Gyro* is the measurement standard deviation of the heading data in degrees.

Discussion: *Gyro* is based on POS/MV manufacturer specifications.

Roll

Error: 0.02

Definition: *Roll* is the measurement standard deviation of the roll data in degrees.

Discussion: *Roll* is based on POS/MV manufacturer specifications.

Pitch

Error: 0.02

Definition: *Gyro* is the measurement standard deviation of the heading data in degrees.

Discussion: *Pitch* is based on POS/MV manufacturer specifications.

Navigation

Error: 0.5

Definition: *Navigation* is the standard deviation associated with the measurement of positions for the vessel in meters.

Discussion: *Navigation* is based on POS/MV manufacturer specifications.

<u>Timing Transducer</u>

Error: 0.0

Definition: *Timing Transducer* is the standard deviation of transducer time stamp measurements.

Discussion: *Timing Transducer* is not known and is currently being researched.

<u>Navigation Timing</u>

Error: 0.0

Definition: *Navigation Timing* is the standard deviation of navigation time stamp measurements.

Discussion: *Navigation Timing* is not known and is currently being researched..

<u>Gyro Timing</u>

Error: 0.01

Definition: *Gyro Timing* is the standard deviation of gyro time stamp measurements.

Discussion: *Gyro Timing* is based on POS/MV manufacturer specifications.

<u>Heave Timing</u>

Error: 0.01

Definition: *Heave Timing* is the standard deviation of heave time stamp measurements.

Discussion: *Heave Timing* is based on POS/MV manufacturer specifications.

<u>Pitch Timing</u>

Error: 0.01

Definition: *Pitch Timing* is the standard deviation of pitch time stamp measurements.

Discussion: *Pitch Timing* is based on POS/MV manufacturer specifications.

<u>Roll Timing</u>

Error: 0.01

Definition: *Roll Timing* is the standard deviation of roll time stamp measurements.

Discussion: *Roll Timing* is based on POS/MV manufacturer specifications.

Sound Velocity Measured

Error:	0.05
Definition:	*Sound Velocity Measured* is the standard deviation of the measurement of sound velocity readings in meters/second.
Discussion:	*Sound Velocity Measured* is based on SEACAT manufacturer specifications.

Surface

Error:	0.05
Definition:	*Surface* is the standard deviation of the measurement of surface sound speed readings in meters/second.
Discussion:	This value is currently being researched. In the meantime, NOAA Ship NANCY FOSTER will use 0.05, which is what NOAA Ship THOMAS JEFFERSON used for its Simrad SSVS.

Tide Measured

Error:	0.01
Definition:	*Tide Measured* is the standard deviation of the measured tide values in meters.
Discussion:	*Tide Measured* is based on CO-OPS calculations.

Tide Zoning

Error:	0.1
Definition:	*Tide Zoning* is the standard deviation of the tide values associated with zoning in meters.
Discussion:	*Tide Zoning* is based on general CO-OPS calculations.

Offset X

Error:	0.02
Definition:	*Offset X* is the standard deviation of the measured X offsets of the vessel.
Discussion:	*Offset X* is the accuracy limit of whatever survey method was used to survey the vessel.

Offset Y

Error:	0.02
Definition:	*Offset Y* is the standard deviation of the measured X offsets of the vessel.
Discussion:	*Offset Y* is the accuracy limit of whatever survey method was used to survey the vessel.

Offset Z

Error: 0.02

Definition: *Offset Z* is the standard deviation of the measured X offsets of the vessel.

Discussion: *Offset Z* is the accuracy limit of whatever survey method was used to survey the vessel.

<u>Vessel Speed</u>

Error: 0.25

Definition: *Vessel Speed* is the standard deviation for the vessel speed measurements in meters/second.

Discussion: *Vessel Speed* requires further research. In the meantime, NANCY FOSTER is using what THOMAS JEFERSON used in 2005.

<u>Loading</u>

Error: 0

Definition: *Loading* is the measurement standard deviation of the vertical changes during the survey because of fuel consumption, etc. *Loading* corresponds to the Caris waterline measurement error.

Discussion: *Loading* is not currently used. Further investigation is required.

<u>Draft</u>

Error: 0.03

Definition: *Draft* is the standard deviation of the vessel draft measurements in meters.

Discussion: *Draft* is the accuracy limit of the draft measuring method.

<u>Delta Draft</u>

Error: 0

Definition: *Delta Draft* is the standard deviation of the dynamic vessel draft measurements in meters.

Discussion: *Delta Draft* is not currently used. Further investigation is required.